FUTURE SPACE PROGRAMS: 1981

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BEFORE THE
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SPACE SCIENCE AND APPLICATIONS
OF THE
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SCIENCE AND TECHNOLOGY
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CONTENTS

WITNESSES

September 21, 1981: Page
- Dr. Melvin Kranzberg, professor of the history of technology, Georgia Tech University 6
- Dr. Marvin Cetron, president, Forecasting International 28
- Dennis Little, specialist futures research and population policy, Science Policy Division, Library of Congress 51

September 22, 1981:
- David Hannah, president, Space Services, Inc 92
- Stan Kent, president, Delta Vee, Inc 111

AFTERNOON SESSION

- Joseph Pascente, president, Electronics Relay, Inc.; Donlin M. Long, Johns Hopkins Hospital; Ronald Moskowitz, president, Ferrofluidics 145

September 23, 1981:
- Dr. W. O. Baker, former president, Bell Laboratories 186
- Gen. Thomas Stafford, USAF (retired), former astronaut, former head of the USAF space programs 214
- John W. Young, Center for Technology Advancement, American University (formerly with OMB) 251
- Hank E. Koehn, vice president, Futures Research Division, Security Pacific National Bank 261

Appendix: Additional statements submitted for the record by Daniel Boorstin and Bruce Friedman 283

FUTURE SPACE PROGRAMS: 1981

MONDAY, SEPTEMBER 21, 1981

House of Representatives,
Committee on Science and Technology,
Subcommittee on Space Science and Applications,
Washington, D.C.

The subcommittee met, pursuant to call, at 2 p.m., in Room 2318, Rayburn House Office Building, Hon. Ronnie G. Flippo (chairman of the subcommittee) presiding.

Mr. Flippo. The committee will come to order.

Today, the Subcommittee on Space Science and Applications opens 3 days of hearings on future space programs. We have a very impressive array of witnesses, but before they begin I would like to say a few words about what we are trying to do in these hearings.

The reason for having these particular hearings at this time is that our civilian space program finds itself at a critical crossroads for many reasons. Among them are that the well-advertised economic recovery plan may fall heavily on discretionary programs such as NASA, there is a new administration in the White House with new philosophies, and there is a new management team in NASA.

The White House has begun a major review of space policy. A cabinet council is studying what to do about remote sensing in space. The Shuttle concept has been demonstrated and will be operational a year from now, giving our Nation new capabilities. There is a lack of long-range goals for our space program.

Our actions of today are governed in part by our perception of the future. If we don't believe there is a future, we won't begin preparing for it, or, if we have a muddled view of the future, we are likely to have muddled plans for that future. Through these hearings we hope to begin to crystallize a view of the future for our space programs.

Of course, what will happen in space is but a small bit of our future. Space is connected to the Earth by the fact that for at least the next 20 years, Earth will be our base; so we have to know where we are going to go on Earth to know where we want to go in space, and vice versa.

If, because our economy is weak, we forsake space programs, this may make our economy yet weaker. For example, we could be poorer by not having the ability to prospect for minerals using remote sensing from space—we may not have the capabilities that space could give us to utilize our Nation's resources in the most effective manner. One specific thing we want to develop in the record of these hearings is those connections between Earth and space.

How are space programs related to employment and productivity and to innovation? We hear of much popular concern about U.S. productivity and innovation, and we hear of ways to increase the one and to reinvigorate the other. I often think that if we want to improve these two factors, what we should do is to *produce* something *new*. It is a lot easier to design and build toward a specific goal than it is to attack such abstract and slippery concepts as "innovation" and "productivity." Obviously, space programs are good places to produce and innovate.

Civilian space programs are an investment in a future that is perceived to be good, and we must make sure that these investments are wise.

I do want to make clear that we are talking about civilian space programs. The military program is related, but it is necessarily separate. We will discuss this interface in the hearings and explore the value of separate civilian programs.

A problem that Congress always faces is having to make decisions with incomplete information. The kinds of decisions needed are not easily subjected to quantitative analysis in any case.

We need to strike balances; for example, science and applications versus the space transportation system. We have to choose emphases. For example, the field of biology is blossoming as a science, but the space program does not contain much biology. Should we do more in that area? Should we do more work on the origin of life?

We need to decide the relative roles of the Government and the private sector in areas such as telecommunications and land remote sensing. Most important of all, it seems we have to set a level of effort. We have to decide how big the budget should be. Such decisions cannot be sound unless we have a clear, consistent long-range goal.

We need as clear a view of the future as possible. Good goals certainly provide a steady aiming point so that programs do not flip-flop, and good goals lead to valid criteria for making the kind of decisions described above.

I hope some of these remarks have clarified our purposes. First of all, I would like to recognize the presence of the ranking member of the full Committee on Science and Technology and other members for their comments.

Mr. WINN. Thank you, Mr. Chairman.

I appreciate those kind words. Let me say that I am looking forward to this series of hearings about the future of the space program. As a matter of fact, there are a lot of us wondering just what the future of the space program is going to hold, particularly because of the President's economic package. Many of us have been trying to get the President to come out very strongly and to make some strong statements that the space program is one of his top priorities. I should add that he has come close a couple of times, but probably not strong enough for those of us that are involved.

At the same time, I would like to point out to many of the people from the scientific community a statement—I don't know who originated the statement, but I think it is very true in our case—that we cannot afford everything that we can think of, and so we might want to keep that in mind as we go through these hearings.

Thank you, Mr. Chairman.

Mr. **Flippo**. And the ranking minority member of the subcommittee, Mr. Hollenbeck.

Mr. **Hollenbeck**. Thank you, Mr. Chairman.

Along with Mr. Winn and the other members of the minority side of the subcommittee, I am looking forward to these 3 days of hearings on future space programs. At times, we are accused of preaching to the choir by asking witnesses to testify before the subcommittee who are from within the space community.

I think it is important to go outside and invite people who have reaped the benefits of space technology, yet were not necessarily involved in the space program.

Therefore, we should hear from entrepreneurs, bankers, industrialists, scientists and doctors and others who will benefit from the technology and business of space and space spinoffs.

When Sputnik was launched in 1957, I think that very few people realized how the ensuing space race between Russia and the United States would come to affect the daily lives of Americans in 1981. Today, a host of satellites such as communications and weather satellites and LANDSAT have become numerous to the point of being commonplace. These satellites are used in weather predictions, crop assessment and predictions and live worldwide television coverage and communication. They also help us to better understand our climate and its changes.

We cannot discuss future space programs without mention of spinoffs. Space spinoffs in microprocessors have completely changed the computer industry by reducing room-size computers to hand-held calculators and desk-top minicomputers increasing capability while reducing energy requirements.

And medical spinoffs are improving the quality of care to patients. A paramedic-operated device transmits a patient's vital body parameters to a hospital for analysis. This virtually brings the doctor to the scene of the accident.

New plastics, lightweight materials and teflon are being used to simulate body tissue. This is useful in designing an artificial heart, reducing scars for burn patients and others receiving skin grafts. We can expect further spinoffs from the space shuttle program which will be the center of the space transportation system for the next 10 to 20 years.

But, Mr. Chairman, can we anticipate what will happen after 20 years? I look forward to the insight of our distinguished panel of witnesses to help this committee guide our space program into the next century.

Thank you.

Mr. **Flippo**. And finally, a valuable member of the subcommittee, Mr. McGrath.

Mr. **McGrath**. Thank you, Mr. Chairman. May I applaud you and others for having the foresight to institute these hearings, just to determine what our future in space programs should and ought to be, and I hope that perhaps we could get into the issues of, Is the space program an economic burden, or is it an investment in our future—things like, if we can't foresee the future, how can we decide and make wise decisions? When should we consider having colonies of men in space. As regards the military, what is the value of a separate civilian-military space program? As far as our international relations are concerned, what role should the United Nations play in our space policy?

As far as applications are concerned, what are the relative roles between the private and Government sectors in our space program? And if we decide that the space program is something which has a future, how and what is the best way this thing called the space program can be sold to the public, given the cost, the great cost?

I am looking forward, as are others, to the answers of our panelists in the next 3 days, and I applaud you for having the insight to institute these hearings.

Mr. FLIPPO. Thank you very much.

Our first witness day will be Dr. Melvin Kranzberg, professor of history of technology at Georgia Tech, a school with a surprising football capability in recent days--as far as the University of Alabama is concerned, certainly.

Dr. Kranzberg has written extensively on the history of technology and his work has been recognized by several honorary degrees and awards. We will open our hearing on the future with a look at history. I think this is wise to do because history certainly records many surprises—many times when the future turned out differently than hoped for. We are delighted to have a man of your capability here today, doctor. Please come forward.

Without objection, we will file your complete statement in the record, and we are delighted to have you. Please proceed as you see fit.

[A biographical sketch of Dr. Kranzberg follows:]

MELVIN KRANZBERG

Melvin Kranzberg (born St. Louis, MO) received his A.B. from Amherst College (1938), and his M.A. (1939) and Ph.D. (1942) from Harvard University. He has received honorary degrees from Denison University, Newark College of Engineering (now New Jersey Institute of Technology), and Northern Michigan University. In May, 1981, Dr. Kranzberg received an honorary doctorate from Worcester Polytechnic Institute.

Dr. Kranzberg served as National President (1979-80) of Sigma Xi, The Scientific Research Society (110,000 active members in 500 chapters and clubs). He was Chairman (1979) of Section L (History and Philosophy of Science) of the American Association for the Advancement of Science (AAAS); Chairman (1978-81) of the AAAS Committee on Science, Engineering, and Public Policy; and Chairman (1977-80) of the Advisory Committee of the Policy Research and Analysis Division and the Division of Science Resources Studies of the National Science Foundation.

Dr. Kranzberg's major professional contribution has been the establishment and development of a new field of history: the history of technology. He is the principal founder of the Society for the History of Technology and editor of its quarterly journal, TECHNOLOGY AND CULTURE; he has been Vice-President of the International Committee for the History of Technology since 1968.

In addition to books on European history (THE SIEGE OF PARIS, 1870-1871 [1950; reprinted hardbound, 1970] and 1848: A TURNING POINT? [1959, 14th printing, 1975]), Dr. Kranzberg published the two-volume TECHNOLOGY IN WESTERN CIVILIZATION (1967; Japanese translation, 1976; Spanish translation, 1980). TECHNOLOGY AND CULTURE: AN ANTHOLOGY (1972) has also appeared in paperbound (1975) and in Arabic (1976) and Spanish (1980) translations. BY THE SWEAT OF THY BROW: WORK IN THE WESTERN WORLD (1975) was a selection of the Fortune Book Club, and was published in paperbound (1976) and in Italian translation (1976). Other works include Patrick Kelly and Melvin Kranzberg, TECHNOLOGICAL INNOVATION: A CRITICAL REVIEW OF CURRENT KNOWLEDGE (1978) and ENERGY AND THE WAY WE LIVE (1980). The latter received a $10,000 prize in an energy education competition from the Academy for Educational Development. Most recently he has published ETHICS IN AN AGE OF PERVASIVE TECHNOLOGY (1980). In addition, Dr. Kranzberg is the author of over 100 papers and articles in encyclopedias, scholarly collections, and learned journals on such topics as engineering education, European history, and the history of science and technology.

Dr. Kranzberg has served as Vice-President of the AAAS; Chairman of the Humanistic-Social Division of the American Society for Engineering Education; Chairman of the Historical Advisory Committee of the National Aeronautics and Space Administration; Vice-President of the Society for French Historical Studies; and Chairman of the United States National Committee of the International Union of the History and Philosophy of Science. He also served on the Technology Assessment Panel of the National Academy of Sciences and on the Academy's Committee on the Survey of Materials Science and Engineering. He is an Advisory Editor of SCIENCE, TECHNOLOGY & HUMAN VALUES and KNOWLEDGE. Dr. Kranzberg was Coordinator of the Course-by-Newspaper on "Energy and the Way We Live," and a commentator on the TV "Connections" series (PBS).

Dr. Kranzberg has taught at Harvard, Stevens Institute, Amherst, and Case Western Reserve University, where he established the first graduate program in the history of technology at any American university. In 1972, he became Callaway Professor of the History of Technology at Georgia Institute of Technology.

Dr. Kranzberg is a member of the following honorary societies: Phi Beta Kappa, Sigma Xi, Epsilon Pi Tau, and Phi Kappa Phi. He has been awarded the Leonardo da Vinci Medal of the Society for the History of Technology (1968); Apollo Achievement Award, NASA (1969); Special Research Day Citation, Case Western Reserve University (1970); Special Recognition Award, Amer Industrial Arts Association (1978); and the Roe Medal, American Society of Mechanical Engineer (1980). In November 1980 Dr. Kranzberg was one of 100 Americans presented the Jabotinsky Centennial Medal by Menachim Begin for eminence in the sciences and letters and for "service to the State of Israel and the Jewish people."

STATEMENT OF DR. MELVIN KRANZBERG, PROFESSOR OF THE HISTORY OF TECHNOLOGY, GEORGIA TECH UNIVERSITY

Dr. KRANZBERG. Mr. Chairman, I am delighted to be here, in order to provide some historical perspective on the space program in very general terms. To emphasize the thrust of my argument, I have subtitled my testimony, "The Future for Space Programs: The 'Top Line'."

I start by looking at an elementary school class today. The teacher asks her class, "What great historical event happened 500 years ago?" Even the stupidest kid in the class will answer with the doggerel: "In fourteen-hundred and ninety-two, Columbus sailed the ocean blue."

Forgotten are other momentous events of the 15th century such as the close of the Hundred Years' War, the War of the Roses, and the fall of Constantinople, which threatened Christendom with extinction by Islam. The political and military events of the 15th century seem insignificant today, although their immediate impact was undoubtedly far greater than that of Columbus' voyage.

We switch now to the 25th century, and the teacher asks the same question. Every hand in the classroom shoots up because every youngster knows the greatest event of the 20th century.

IN NINETEEN-HUNDRED AND SIXTY-NINE
NEIL ARMSTRONG LEAPED FOR ALL MANKIND

To those of us living in the 20th century other developments loom larger in their impact upon our times. After all, our century has witnessed two world wars, the rise and decline of fascist dictatorships, the spread of Communist ideology, and the end of colonial empires.

Then there are a whole host of mundane considerations which affect our daily lives: the cost of living, urban crime, the energy crisis, and the like. Yet all of these will eventually be relegated to historical footnotes when compared with man's first steps into space. Thus, within a few centuries, the process of winnowing out the historically important from transient and ephemeral events will have singled out man's first landing on the Moon as the most significant development of our times.

Yet some contemporary social critics claim that America's space efforts have had a negative effect; that they have been harmful and deleterious to our society. Amitai Etzioni, for example, characterized Project Apollo as "the last gasp of a technologically addicted, public-relations-minded society, the last escapade engineered by an industrial-military coalition seeking conquests in outer space, while avoiding swelling needs on Earth."

Others take a similar pessimistic view, including some of the dispossessed of our society who see their own problems go unredressed while billions of dollars are spent on space ventures which seem to provide no immediate or direct benefit to them.

However, the critics of our space program disregard the political, economic, and scientific returns which it has already yielded and neglect entirely the future benefits to be derived from it.

First we must remember that Project Apollo was politically inspired. Although President John F. Kennedy said we must go to the Moon "because it is there," historical investigations have established that the decision to land on the Moon was part of America's waging of the Cold War. Stung by the ignominious failure of the Bay of Pigs invasion, President Kennedy sought to retrieve the national "honor" by some startling and impressive act. What could be better than the reassertion of America's scientific and technological primacy—a superiority which had been rudely shaken a few years earlier by the flight of Sputnik and then by Yuri Gagarin's first orbiting of the Earth?

America won the "space race," but one can doubt if this amounted to a Cold War victory, for the gradual thawing of American-Soviet relations had little to do with America's accomplishments in space.

Nevertheless, there is no doubt that we derived incalculable political benefits in raising America in the world's esteem by our demonstration of scientific-technological supremacy. It is estimated that some 600 million people—almost half the world population—watched or heard the landing on the Moon. Ever since then, the Russians have been playing "catchup ball," trying to retrieve their initial space triumphs by other space activities which pale into insignificance when compared with our spectacular accomplishments.

Let me give you a personal anecdote which, I think, represents the continuing Russian envy of our commanding position in space.

As a participant in international scholarly meetings in the history of science and technology, I frequently received after 1957 little enamel lapel pins from the Russians depicting Sputnik and then, after 1961, little pins showing Yuri Gagarin. I bit my tongue and bided my time.

My time came at the XIIIth International Congress of the History of Science, held in 1971 in Moscow. There I was able to present my Russian colleagues with sets of U.S. postage stamps commemorating man's first landing on the Moon. Their envy was obvious, as was the admiration of those scholars from other countries to whom I presented sets. All of us Americans "walked taller" because our countrymen had walked on the Moon.

Even today, when some mistakenly believe that America's international prestige is low, let me assure you that we still retain the esteem of people around the world for our scientific and technological prowess, manifested by our continuing triumphs in space activities, most recently the Saturn "flyby."

In addition to what might be termed America's morale victory over the Soviet Union, it became apparent that space flight could be a means for advancing international cooperation rather than fueling national rivalries. A 1972 pact between the United States and the Soviet Union for cooperation in space culminated in the Apollo-Soyuz flight some years later.

Our space program, fulfilling its original purpose before Sputnik partially diverted it into a political instrument, also brought rich scientific rewards. Information derived from the Moon—by photographs, lunar samples, and various measurements—cast new light upon age-old speculations regarding the cosmos. We still do not know how the Moon was formed; it evidently has its own complex history and evolution, and the scientific efforts of Project Apollo have shown us that much more is still to be learned.

Similarly, the close views of the planets, made possible by the Pioneer, Voyager, and Mariner probes, have astounded scientists in showing the diversity of these heavenly bodies. Although some old myths have been dispelled, new mysteries and questions now confront us regarding the origins and nature of the elements of our solar system and of the entire cosmos.

In addition, we have acquired a great deal of information regarding space flight itself, the effects of a gravity-free environment upon human physiology, and many other aspects of the life sciences and of physical and astrophysical sciences.

To the man in the street, however, the scientific results might seem meager in terms of tangible rewards to man on Earth. Yet NASA can point to some very specific benefits as a result of spin-offs of our space efforts; for example, the development of fuel cells and miniaturized computers derived directly from the space program. NASA took very seriously its responsibility to share the scientific and technological knowledge acquired in the space program with the public, and established a large-scale technology utilization project to spread that knowledge to the civilian economy.

Furthermore, weather satellites, communications satellites, and now Earth resource satellites—direct products of NASA's space efforts—have already provided vast economic benefits to this country and to mankind as a whole, and promise even greater benefits in the future.

Just as the proceeds from Columbus' four voyages can scarcely be said to have repaid the interest on Queen Isabella's pawning of her jewels, the scientific and technical benefits of our space program have perhaps not yet justified the expenditure of billions of dollars. However, just as the throne of Spain eventually was to reap great profits from the New World, so our earthbound society might ultimately derive munificent economic returns from our space expenditures.

Actually, our space program might already have more than paid for itself by indirect and incalculable economic rewards. Because of the interdependent nature of today's complex technology, many advances in the information, health, materials, and energy fields are linked with the scientific and technological efforts of the space programs, although direct lines of causation are difficult to unravel.

Similarly, America's renewed efforts in science and engineering education during the past two decades were at least partially fueled by our space efforts. Although we cannot attribute all of our recent scientific-technical progress directly to space expenditures, it should be noted that these helped create the economic and educational preconditions for further advances in many different scientific and technical fields.

But history is more than cost accounting. The true value of our space program in historical perspective might lie more in its intangible rewards to mankind rather than in benefits measurable in terms of dollars and cents.

If we view the space program in the vast panorama of history, we find that it represents the apex of scientific and technical trends which commenced with the 17th century scientific revolution and the 18th century industrial revolution and, indeed, represents the culmination of man's dreams of flight beyond the confines of our own planet.

Furthermore, it corresponds to two of Western man's most fundamental traits: Man's pursuit of knowledge and his drive to conquer nature. Throughout history, man's most abiding quest has been his attempt to understand himself in relation to the cosmos. By providing us with new knowledge and new questions—about the universe outside ourselves—the space program has attempted to fulfill this age-old longing. And, of course, there could be no greater demonstration of Western man's Faustian desire to control the forces of nature than his ability to lift himself off this planet, set foot on the moon, and explore the vast expanse of the cosmos.

Equally intangible but no less profound in its significance has been the impact of the space program on man's perception of his own Earth. Just as the Copernican Revolution revolutionized man's view of himself in relation to the cosmos, with incalculable results for the religious and philosophical outlook of Western man, so the space program has given us a new global consciousness as we become aware of the finitude of our own planet.

Even before Project Apollo took form, the concept of Spaceship Earth had been enunciated, but to most people this was a nebulous idea with little concrete meaning. The space program gave visual content to what had previously been a vague abstraction: For the first time everyone could see the Earth whole, in all its fragility and loneliness.

As more information about the realm of space reaches us, the possibility of some form of intelligent life on the other planets of our solar system is gradually receding from our speculations. If we have neighbors in the cosmos, they must be billions or trillions of light years away, unable to reach us or for us to reach them for generations to come.

Our religious traditions have long told us of the uniqueness of man and of this Earth; now our science verifies this. For all practical purposes, we are alone on this Earth—and there is no other home for us, in practicable terms, in the rest of the universe, despite the visionary dreams of space colonies. At least for the foreseeable future, we must do with what we have. Hence, our efforts to preserve the biosphere and to use our finite material resources to the best of our ability are no longer just moralistic preachings but pragmatic imperatives for the survival of our species and planet.

If the knowledge of the uniqueness of man on Spaceship Earth gives rise to loneliness, that is no cause of despair. If anything, the success of our space programs thus far should revive hope and provide inspiration for greater achievement in the future. At a time when the fabric of our American society seems to be splitting asunder, when traditional values are challenged, and when security and freedom are threatened, our space achievements help revive our faith in man's capacities and the American ability to get things done.

By working together, by marshaling men, money, resources, and knowledge, as was done in our space program, we know that we can stretch human capabilities still farther. This should give us hope that we can deal with the many other problems which beset us, and perhaps what we most need is a revival of faith in ourselves.

So, my plea is that we forgo for a time our concentration on the "bottom line." For a change let us turn our thoughts, our dreams, and our hopes, to the great vistas envisioned in the "top line": To the human compulsion to understand the universe so that we can better know ourselves, to comprehend the cosmos despite the new mysteries with which it confronts us, and to stretch the boundaries of our imagination and ingenuity to meet the scientific and technical challenges posed by the human adventure embodied in our space program.

That is the "top line" of our humanity, for we are more—much more—than animal creatures. Underneath, or perhaps in this context I should say "above", the nitty-gritty of the space program, the organizational structure, the scientific questions and technical problems, the proper disposition of human and material resources, stands its role as an embodiment of man's noblest aspirations of knowing and doing.

However, I am no empty idealist. I realize that our space program must function in the real world of conflicting economic, political, and social pressures. For man is an animal creature, too, so that attention must be paid to the bottom as well as the top line. For that, some historical perspective might be helpful.

Yet, just as observers in Seville could not have foretold the consequences of Columbus' voyage when he returned to Spain in 1493, it is still too early for us to judge the full impact of the space program. Its historical impact will not be apparent for many years, or perhaps even centuries to come. It is not left to us but to men of the future to evaluate the results of our first steps into space.

But history can tell us one thing about the future judgments of our space efforts. Although we might quarrel with one another about the program's benefits, our descendants will look back upon our times and our generation with respect and awe. For future generations will undoubtedly take up the quest for knowledge and the conquest of space where we leave off; in their wanderings in the cosmos, they will recall with fascination and admiration their 20th century ancestors who possessed the will, the courage, and the means to make the giant leap into extraterrestrial adventures.

Despite good intentions and hard efforts, we can scarcely say that we are leaving a happy, peaceful, and prosperous world to those who follow us. But there is one exception to this melancholy legacy which we leave to posterity. That exception is the triumph of the human mind and spirit exemplified by our space effort. It affords an example of what can be accomplished by human knowledge, imagination, ingenuity, skill, and cooperation. In that way it provides us with the most meaningful legacy we can leave to the future: hope.

[The prepared statement of Dr. Kranzberg follows:]

Subcommittee on Space Science and
Applications
House Committee on Science and
Technology
Washington, DC
September 21, 1981

Dr. Melvin Kranzberg
Callaway Professor of the History
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ORAL TESTIMONY

The Future for Space Programs: The "Top Line"

The time is today, and the teacher asks her class, "What great historical event happened 500 years ago?" Even the stupidest kid in the class will answer with the doggerel,

In fourteen-hundred and ninety-two
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Forgotten are other momentous events of the 15th century such as the close of the Hundred Years' War, the Wars of the Roses, and the fall of Constantinople, which threatened Christendom with extinction by Islam. The political and military events of the 15th century seem insignificant today, although their immediate impact was undoubtedly far greater than that of Columbus's voyage.

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In nineteen-hundred and sixty-nine
Neil Armstrong leaped for all mankind.

To those of us living in the 20th century other developments loom larger in their impact upon our times. After all, our century has witnessed two world wars, the rise and decline of fascist dictatorships, the spread of communist ideology, and the end of colonial empires. Then there are a whole host of mundane considerations which affect our daily lives: the cost of living, urban crime, the energy crisis, and the like. Yet all of these will eventually be relegated to historical footnotes when compared with man's first steps into space. Thus, within a few centuries, the process of winnowing out the historically important from transient and ephemeral events will have singled out man's first landing on the moon as the most significant development of our times.

Yet, some contemporary social critics claim that America's space efforts have had a negative effect, that they have been harmful and deleterious to our society. Amitai Etzioni, for example, characterized Project Apollo as "the last gasp of a technologically addicted, public-relations-minded society, the last escapade engineered by an industrial-military coalition seeking conquests in outer space, while avoiding swelling needs on earth."

Others take a similar pessimistic view, including some of the dispossessed of our society who see their own problems go unredressed while billions of dollars are spent on space ventures which seem to provide no immediate or direct benefit to them.

However, the critics of our space program disregard the political, economic, and scientific returns which it has already yielded and neglect entirely the future benefits to be derived from it.

First we must remember that Project Apollo was politically inspired. Although President John F. Kennedy said we must go to the moon "because it is there," historical investigations have established that the decision to land on the moon was part of America's waging of the Cold War. Stung by the ignominious failure of the Bay of Pigs invasion, Kennedy sought to retrieve the national "honor" by some startling and impressive act. What could be better than the reassertion of America's scientific and technological primacy--a superiority which had been rudely shaken a few years earlier by the flight of Sputnik and then by Yuri Gagarin's first orbiting of the earth?

America won the "space race," but one can doubt if this amounted to a Cold War victory, for the gradual thawing of American-Soviet relations had little to do with America's accomplishments in space.

Nevertheless, there is no doubt that we derived incalculable political benefits in raising America in the world's esteem by our demonstration of scientific-technological supremacy. Some 600,000,000 people--almost half the world's population--watched or heard the landing on the moon. Ever since then, the Russians have been playing "catchup ball," trying to retrieve their initial space triumphs by other space activities which pale into insignicance when compared with our spectacular accomplishments.

Let me give you a personal anecdote which, I think, represents the continuing Russian envy of our commanding position in space.

As a participant in international scholarly meetings in the history of science and technology, I frequently received after 1957 little enamel lapel pins from the Russians depicting Sputnik and then, after 1961, little pins showing Yuri Gagarin. I bit my tongue and bided by time. My time came at the XIVth International Congress of the History of Science, held in 1971 in Moscow. There I was able to present my Russian colleagues with sets of U. S. postage stamps commemorating man's first landing on the moon. Their envy was obvious, as was the admiration of those scholars from other countries to whom I presented sets. All of us Americans walked "taller" because our countrymen had walked on the moon.

Even today, when some mistakenly believe that America's international prestige is low, let me assure you that we still retain the esteem of people around the world for our scientific and technological prowess, manifested by our continuing triumphs in space activities, most recently the Saturn "flyby."

In addition to what might be termed America's "morale victory" over the Soviet Union, it became apparent that space flight could be a means for advancing international cooperation rather than fueling national rivalries. A 1972 pact between the United States and the Soviet Union for cooperation in space culminated in the Apollo-Soyuz flight some years later.

The space program, fulfilling its original purpose before Sputnik converted it into a political instrument, also brought rich scientific rewards. Information derived from the moon--by photographs, lunar samples, and various measurements--cast new light upon age-old speculations regarding the cosmos. We still do not know how the moon was formed; it evidently has its own complex history and evolution, and the scientific efforts of Project Apollo have shown us that much more is still to be learned. Similarly, the close views of the planets, made possible by the Pioneer, Voyager, and Mariner probes, have astounded scientists in showing the diversity of these heavenly bodies. Although some old myths have been dispelled, new mysteries and questions now confront us regarding the origins and nature of the elements of our solar system.

In addition, we have acquired a great deal of information regarding space flight itself, the effects of a gravity-free environment upon human physiology, and many other aspects of the life sciences and of physical and astrophysical sciences.

To the man in the street, however, the scientific results might seem meager in terms of tangible rewards to man on earth. Yet NASA can point to some very specific benefits as a results of "spinoffs" of our space efforts, For example, the development of fuel cells and miniaturized computers derived directly from the space program. NASA has taken very seriously its responsibility to share the scientific and technological knowledge acquired in the space program with the public, and has established a large-scale technology utilization project to spread that knowledge to the civilian economy.

Furthermore, weather satellites, communications satellites, and now earth resource satellites--direct products of NASA's space efforts--have already provided vast economic benefits to this country and to mankind as a whole--and promise even greater benefits in the future.

Just as the proceeds from Columbus's four voyages can scarcely be said to have repaid the interest on Queen Isabella's pawning of her jewels, the scientific and technical benefits of our space program have perhaps not yet justified the expenditure of billions of dollars. However, just as the throne of Spain eventually was to reap great profits from the New World, so our earthbound society might ultimately derive munificent economic returns from our space expenditures.

Actually, our space program might already have more than paid for itself by indirect and incalculable economic rewards. Because of the interdependent nature of today's complex technology, many advances in the information, health, materials, and energy fields are linked with the scientific and technological efforts of the space programs, although direct lines of causation are difficult to unravel. Similarly, America's renewed efforts in science and engineering education during the past two decades were at least partially fueled by our space efforts. Although we cannot attribute all of our recent scientific-technical progress directly to space expenditures, it should be noted that these helped create the economic and educational preconditions for further advances in many different scientific and technical fields.

* * *

But history is more than cost accounting. The true value of our space program in historical perspective might lie more in its intangible rewards to mankind rather than in benefits measurable in terms of dollars and cents.

If we view the space program in the vast panorama of history, we find that it represents the apex of scientific and technical trends which commenced with the 17th-century Scientific Revolution and the 18th-century Industrial Revolution and, indeed, represents the culmination of man's dreams of flight beyond the confines of our own planet.

Furthermore, it corresponds to two of Western man's most fundamental traits: Man's pursuit of knowledge and his drive to conquer nature. Throughout history, man's most abiding quest has been his attempt to understand himself in relation to the cosmos. By providing us with new knowledge and new questions--about the universe outside ourselves--the space program has attempted to fulfill this age-old longing. And, of course, there could be no greater demonstration of Western man's Faustian desire to control the forces of nature than his ability to lift himself off this planet, set foot on the moon, and explore the vast expanse of the cosmos.

Equally intangible but no less profound in its significance has been the impact of the space program on man's perception of his own earth. Just as the Copernican Revolution revolutionized man's view of himself in relation to the cosmos, with incalculable results for the religious and philosophical outlook of Western man, so the space program has given us a new global consciousness as we become aware of the finitude of our own planet. Even before Project Apollo took form, the concept of Spaceship Earth had been enunciated, but to most people this was a nebulous idea with little concrete meaning. The space program gave visual content to what had previously been a vague abstraction: For the first time everyone could see the earth whole, in its fragility and loneliness.

As more information about the realm of space reaches us, the possibility of some form of intelligent life on the other planets of our solar system is gradually receding from our speculations. If we have neighbors in the cosmos, they must be billions or trillions of light years away, unable to reach us or for us to reach them for generations to come. Our religious traditions have long told us of the uniqueness of man and of this earth; now our science verifies this. For all practical purposes, we are alone on this earth--and there is no other home for us, in practicable terms, in the rest of the universe, despite the visionary dreams of space colonies. At least for the foreseeable future, we must do with what we have. Hence our efforts to preserve the biosphere and to use our finite material resources to the best of our ability are no longer just moralistic preachings but pragmatic imperatives for the survival of our species and planet.

If the knowledge of the uniqueness of man on Spaceship Earth gives rise to loneliness, that is no cause for despair. If anything, the success of our space programs thus far should revive hope and provide inspiration for greater achievement in the future. At a time when the fabric of our American society seems to be splitting asunder, when traditional values are challenged, and when security and freedom are threatened, our space achievements help revive our faith in man's capacities. By working together, by marshalling men, money, resources, and knowledge as was done in our space program, we know that we can stretch human capabilities still farther. This should give us hope that we can deal with the many other problems which beset us—and perhaps what we most need is a revival of faith in ourselves.

* * *

So, my plea is that we forego for a time our concentration on the "bottom line." For a change let us turn our thoughts, our dreams, and our hopes, to the great vistas envisioned in the "top line": To the human compulsion to understand the universe so that we can better know ourselves, to comprehend the cosmos despite the new mysteries with which it confronts us, and to stretch the boundaries of our imagination and ingenuity to meet the scientific and technical challenges posed by the human adventure embodied in our space program.

That is the "top line" of our humanity, for we are more--much more--than animal creatures. Underneath (or perhaps in this context, I should say "above") the nitty-gritty of the space program--the organizational structure, the scientific questions and technical problems, the proper disposition of human and material resources--stands its role as an embodiment of man's noblest aspirations of knowing and doing.

However, I am no empty idealist. I realize that our space program must function in the real world of conflicting economic, political and social pressures. For man is an animal creature too, so that attention must be paid to the bottom as well as the top line. For that, some historical perspective might be helpful.

Yet, just as observers in Seville could not have foretold the consequences of Columbus's voyage when he returned to Spain in 1493, it is still too early for us to judge the full impact of the space program. Its historical impact will not be apparent for many years, or perhaps even centuries to come. It is not left to us but to men of the future to evaluate the results of our first steps into space.

But history can tell us one thing about the future judgments of our space efforts. Although we might quarrel with one another about the program's benefits, our descendants will look back upon our times and our generation with respect and awe. For future generations will undoubtedly take up the quest for knowledge and the conquest of space where we leave off; in their wanderings in the cosmos, they will recall with fascination and admiration their 20th-century ancestors who possessed the will, the courage, and the means to make the giant leap into extraterrestrial adventures.

Despite good intentions and hard efforts, we can scarcely say that we are leaving a happy, peaceful, and prosperous world to those who follow us. But there is one exception to this melancholy legacy which we leave to posterity. That exception is the triumph of the human mind and spirit exemplified by our space effort. It affords an example of what can be accomplished by human knowledge, imagination, ingenuity, skill, and cooperation. In that way it provides us with the most meaningful legacy we can leave to the future: hope.

Mr. FLIPPO. Thank you very much, Doctor, for your excellent testimony.

You seem to be saying that expenditures of this nature are part of the solution to our problems rather than a part of the problem. You made, I thought, some eloquent statements about making us have faith in ourselves. Could you give us some other examples in history when a space program type of event occurred that led to a revival of self-confidence in other societies, or in this country?

Mr. KRANZBERG. Well, in this country, the way we pulled together in World War II would be an example of the accomplishments of a united national will, we put men, money, talents, resources together to accomplish a national goal. That was one of the last times we were able to do that until the space program.

Mr. FLIPPO. You are knowledgeable in the history of technology. Could you comment on the role technology has played in the rise and fall of civilizations or the rise and fall of nations?

Mr. KRANZBERG. Yes. I have several courses about that, but we don't have time for that today. However, let me give you a brief example.

I think one of the reasons for the fall of the Roman Empire, among other reasons, was that it was facing an energy crisis, an energy crisis which it failed to resolve. That energy crisis was caused by the fact that the Roman Empire depended for its energy upon human muscle power—human muscle power supplied largely by slaves.

However, beginning about the third century, the Romans began having a decline in their energy because the empire was no longer expanding, so they were no longer taking slaves from conquered people. Furthermore, the introduction of Christianity militated against slavery. Now the Roman Empire endeavored to resolve this problem, to conserve its supply of human muscle power by binding men to their occupations. But that didn't work. They just didn't provide sufficient muscle power, enough energy to keep the Empire going.

Now, this is not the only reason the Roman Empire fell, but they didn't recognize this energy crisis as such. It was to take some time before technical developments in the Middle Ages were able to compensate for the energy crisis which caused the Roman Empire to fall. The lesson is that we have to conquer our energy crisis, too.

Mr. FLIPPO. Do you see any particular advantage of research and development expenditures on the space program as compared to R. & D. expenditures on any other type of R. & D.?

Dr. **Kranzberg**. As I pointed out, modern science and technology are so interdependent that advances in space research and development also impinge upon the civilian economy by spinoffs. Miniaturization, computers, and so forth, all of these get put together to raise the scientific-technological level of our entire society.

Mr. **Flippo**. The rising tide raises all ships.

Mr. **Kranzberg**. That is right.

Mr. **Flippo**. Mr. Winn?

Mr. **Winn**. Thank you, Mr. Chairman.

Doctor, I admire your enthusiasm for history and how you have tied it in with the space program. Obviously that is why you are here today.

It is a pretty well-known fact now that they are having trouble interesting young students in engineering and in some of the sciences. Have you, in any of your studies, or your history research, felt that an event like the Shuttle, maybe after a time lag, would stimulate young people to want to be engineers and scientists, to possibly help fill the gap that is developing now?

Dr. **Kranzberg**. Oh, yes. I think we can see this by changing trends in enrollment in science and engineering, depending upon what happens to be in the news, at the time. For example, enrollments in nuclear studies, and nuclear physics went up following World War II because of the discovery of nuclear power. Nowadays, you have great growth in information, and computer sciences because of great interest—and opportunities—in that field. Development of environmental sciences occurred because that came to public attention; and so there is no doubt that enlarged interest in the aeronautical and aerospace science and engineering will derive from America's further conquests in space.

Mr. **Winn**. When we get that stimulus, however, we sometimes develop, as in the environmental field, an antifeeling, an anti-whatever industry or science is developing. We see that in the paper and on TV all this last week, for instance. Not a constructive direction, but sometimes a destructive direction, and to try to find the balance seems to me to be a real, real problem.

Dr. **Kranzberg**. I agree with you, Mr. Winn. I don't think you find that in our science and engineering schools such as Georgia Tech, because our students are pretty much professionally committed. True, those students in environmental sciences or solar energy will argue with those in nuclear energy, but it is in a constructive way; they are not antiscience or antitechnology but, rather, they dispute over which science and/or technology to apply and to which problems. On the other hand, most of antitechnology feeling comes from people who do not know about the human nature of technology or the interactions of technology and science with society. Therefore, we have to do a lot to inculcate understanding of science and technical knowledge in nonscientists and nonengineers.

Mr. **Winn**. I agree. How do we do it?

Dr. **Kranzberg**. Well, it is very difficult to do. I keep telling my fellow historians: History is a series of questions we ask of the past in order to understand how the present got to be what it is. We call ours a scientific and technological age. How did it get to be that way? What are you teaching to your classes, to inform them how science and technology helped develop our civilization into this scientific and technological age? Alas, the fact is that most of my historian colleagues keep teaching the same old way they have done before; namely, history as politics and diplomacy, and not very much about the development of science and technology and their interactions with society, which have helped to make us what we are today.

Mr. **Winn**. Your statements are right down the alley as far as I am concerned. We all want to be policemen or firemen, and I don't think that is the big thing any more. Then a lot of kids want to be astronauts, and I am not sure that we haven't lost that edge of where kids want to be astronauts. They are still interested in space. That is obvious by some of the types of movies that are selling, and a couple of my grandchildren around 4 or 5 years old can tell me a lot about some space toys that are on the market now based on those movies and television shows, but I am not sure.

I represent the University of Kansas, and we have a very fine engineering school there, as you well know. When I meet with some of the students, I am not sure that they are sure that is what they want to do for a livelihood. That is what I am trying to say. They want to be an engineer, but there are some questions that kind of bother me. Many of them don't have an absolute, absolute dedication that I think that it takes.

Dr. **Kranzberg**. I disagree with you. I have lectured at the University of Kansas, and I know some of your students and professors there, and I know my own students with whom I am in daily contact. It is true, our youth want to get good jobs, but they also have the ideal of service to mankind. I think that is great because they are combining the pragmatism and the idealism which have helped make this country great; I still find those qualities in large measure now among young students today. That is what gives me hope for the future.

Mr. **Winn**. Very good. I am glad to hear that.

Thank you, Doctor.

Thank you, Mr. Chairman.

Mr. **Flippo**. Mr. Hollenbeck?

Mr. **Hollenbeck**. We find when we talk to NASA people that at times we are somewhat frustrated because the public in general does not understand the value of the space program. They don't generally relate the benefits of the space program to themselves, to the average man in the street.

From your perspective, how might the committee, NASA, or private industry, pursue the goal of a better educated and more informed and appreciative public?

Dr. **Kranzberg**. Well, I think we have to start way back and get some appreciation of science and technology from the very beginning of our education, and this is what we are lacking. The other thing you are talking about, public relations, I am not an expert on this. I am supposed to be an expert on education, and I think we have to educate first our primary school teachers and our secondary school teachers so that they can inculcate a fuller understanding of science and technology into their students.

Mr. **Hollenbeck**. That would be more successful and penetrating in the long run than a public relations program.

Dr. **Kranzberg**. Yes.

Mr. **Hollenbeck**. Now in the space applications area which you have alluded to in your testimony, we have both industry and commercial ventures playing a role. We run into a debate over the appropriate role of our government vis-a-vis the role of private industry.

Can you comment from a historical perspective, possibly on the relationship between development and industry under our form of government and the relationship of government and industry in, say, Western Europe and Japan since World War II?

Dr. **Kranzberg**. Yes. In Western Europe and in Japan, the government has taken a more direct role in guiding industry than we have, but throughout American history our Government has supported industry in various ways, sometimes simply by a laissez faire, hands-off attitude; other times by direct or indirect help.

We speak in Jeffersonian rhetoric, but actually our country's future belonged to Alexander Hamilton. We live in a Hamiltonian world, where the government actively assists industry—and sometimes actually assists industry by being inactive, if you know what I mean.

This has characterized American growth in the past and will do so in the future. However, I do think that the times require that the government today play a more active role as a middleman in stimulating industry and universities to get together to advance our knowledge and advance our technology.

Mr. **Hollenbeck**. Thank you, Mr. Chairman.

Mr. **Flippo**. Thank you.

Mr. McGrath?

Mr. **McGrath**. Thank you, Mr. Chairman.

Dr. Kranzberg, I was very interested in your analysis of the history of the program and particularly your observations on the sailing of Columbus in 1492, and if the past is prologue, and analogous to that, the colonization of the new world, I am wondering whether or not you could offer to us any analogy of the beginning of, I should say, the completion of the Shuttle program—I shouldn't say the beginning of the Shuttle program now, as it relates perhaps to colonization of a new world as outlined by a chap named O'Neill, who believes in the L-5-type program for colonization of space.

Dr. **Kranzberg**. I don't quite agree with Mr. O'Neill. Perhaps that is because I am older.

When I was young, I used to worry about the Sun cooling off a couple of billion years from now. I no longer worry about that, because I know that I won't be around; but I am pleased to tell you that my students worry about the Sun cooling off several billion years from now. Maybe Mr. O'Neill can see a little further than I can. I have 20-20 hindsight; I am a historian, but I haven't 20-20 foresight. I don't think that space colonization is in the cards for the immediate future.

Mr. **McGrath**. How much into the future might that be in your estimates as a historian, with knowledge of the space program that you have?

Dr. **Kranzberg**. A couple of hundred years.

Mr. **McGrath**. I hope I am around.

Mr. **Flippo**. Thank you, Mr. McGrath.

Doctor, thank you very much for your testimony. It has been very helpful to us, and we appreciate your coming and sharing your views with us.

Our next witness is Dr. Marvin Cetron. We have had a look at history and had a historical perspective about it. Now we want to look to the future.

Dr. Cetron is a president of Forecasting International, Limited. He has participated in a 1975 study on future space programs done by NASA. He has consulted for the Joint Chiefs of Staff and several major corporations on future research, and he has lectured and published widely in his field.

We are very pleased to have you with us today. We will be pleased to receive your testimony for the record, without objection, and have you summarize.

For the information of the members of the committee, Dr. Cetron has a plane to catch, I believe, at 3:15, or has to leave somewhere in that neighborhood.

Dr. Cetron. Between 3:15 and 3:30 I must leave, as I have a meeting.

Mr. Flippo. Thank you very much for being with us.

[A biographical sketch of Dr. Cetron follows:]

FORECASTING INTERNATIONAL, Ltd.

STAFF RESUME

MARVIN J. CETRON

President

SUMMARY: Dr. Cetron is the founder and president of Forecasting International. A pioneer and expert in the areas of technological forecasting and technology assessment, he has structured FI to provide industry and government with the benefits and insights of an international group of experts in the fields of management techniques; technological forecasting; corporate strategic planning; technology assessment; R&D planning; project selection; resource allocation; economics; marketing and the behavioral sciences. Dr. Cetron has had extensive consulting experience with government agencies, foreign governments and industry.

EDUCATION: B.S. in Industrial Engineering, Pennsylvania State University. M.S. in Production Management, Columbia University. Ph.D. in Research and Development Management, American University.

PROFESSIONAL EXPERIENCE:

Forecasting International, Ltd. (Since June 1971). Dr. Cetron contributes to and provides continuing guidance and supervision to the majority of FI studies. Some specific areas in which he has contributed and directed operations are:

International:	"System Stability and Business Attractiveness of Selected Latin American Countries: Projections to 1995" and "System Stability of Twenty-one Nations."
Corporate:	"Three Alternative Scenarios for the Office of the Future," "Assessment of the Attractiveness of Selected European Countries for Consumer Financial Services" and "The Future Environment and Its Effects on Several Consumer Products Manufacturers."
Aviation:	"How Technology Transfer Affects the Competitive Position of the U. S. in the Aviation Market."
Communications:	"The Impact of Bidirectional Broadband Communications on the Urban Environment" and "Potential Impacts of Telecommunications Technology on U. S. Cities 1973-2000."

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STAFF RESUME

MARVIN J. CETRON

Electronics:	"Analysis of the Implications of Electronic Funds Transfer on Selected Social Parameters."
Housing:	"Public Housing Management: A Synopsis and State-of-the-Art Bibliographies."
Medical:	"A Medical and Health Care Scenario of the Future."
Energy Conservation:	"A Resource Allocation Model" for the ERDA Conservation Program.
Environment:	"Development of a Management Tool to Aid in the Allocation of Resources"; Forecast of Future Environmental Protection Requirements and Their Implications for Army R&D."
Energy:	"Societal and Political Implications of the Energy Crisis," "A Technological Forecast of the Coal Industry," and "Energy and the European Economic Community."
Technology Assessment:	"State-of-the-Art and Bibliography of Available Forecastings" and "Pre-definition Phase Study of How a Technology Assessment Might be Run for the EEC."
Marine:	"Development of a Program Assessment Model for the U. S. Coast Guard."
Management:	"A Study of Political Improvements to the U. S. Army Materiel Command's Product Improvement Program."
Future Environment:	"Europe in the Year 2000", "Problems, Crises and Issues in the Future Environment."
Consumerism:	"Sweden as a Precursor Nation."

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STAFF RESUME

MARVIN J. CETRON

U. S. Navy (19 years). Dr. Cetron completed a career in R&D planning and forecasting with the U. S. Navy, both in its laboratories as Assistant to the Technical Director at the Applied Science Laboratory and Head of Planning at the Marine Engineering Laboratory, and as Head of Planning for Exploratory Development at Headquarters, Naval Material Command in Washington. During his work with the Navy, he was in charge of the design, development and implementation of the most comprehensive technological forecast in the United States.

Consulting Experience. He has been a consultant to First National City Bank, General Motors, B&W Tobacco, Colgate, Clorox, GT&E, Union Carbide, Xerox, IBM, Mead-Johnson, the U. S. National Academy of Engineering, the Royal Swedish Academy of Engineering Science, National Science Foundation, UNESCO, OECD, the Common Market, and to many foreign governments, including most recently, the Brazilian Ministry of Planning, Kenyan Ministry of Finance, and the Yugoslavian Ministry of Economics.

Professorial Experience. Dr. Cetron is Adjunct Professor at American University and teaches graduate courses at MIT, Georgia Tech, and George Washington University. In addition, he has lectured extensively throughout the world on technological forecasting, technology assessment, and R&D planning.

OTHER ACTIVITIES:

He was also Editor-in-Chief of the Technology Assessment Journal and is on the Editorial Advisory Board of Technological Forecasting and Social Change and the IEEE Transactions on Engineering Management. He is also a member of the Coast Guard R&D Advisory Committee.

PUBLICATIONS:

Along with numerous articles, papers and publications, he has authored, coauthored, or edited ten books on quantitative R&D planning:

Technological Forecasting: A Practical Approach, Gordon and Breach, 1969.

Technical Resource Management: Quantitative Methods, MIT Press, 1970.

STAFF RESUME

MARVIN J. CETRON

The Science of Managing Organized Technology, (4 Vols.), Gordon and Breach, 1971.

Industrial Applications of Technological Forecasting: Its Use in R&D Management, John Wiley and Sons, Inc., 1971.

The Navy Technological Forecast, 1968, 1969, and 1970.

Technology Assessment in a Dynamic Environment, Gordon and Breach, 1972.

The Methodology of Technology Assessment, Gordon and Breach, 1972.

Quantitative Decision-aiding Techniques for R&D Management , Gordon and Breach, 1972.

Proceedings of the NATO Advanced Study Institute on Technology Transfer, Nordhoff Press, Holland, 1974.

Industrial Technology Transfer, Nordhoff Press, Holland, 1977.

The first two of these books were awarded the ARMED FORCES MANAGEMENT LITERARY AWARDS in 1969 and 1970, respectively.

STATEMENT OF DR. MARVIN CETRON, PRESIDENT, FORECASTING INTERNATIONAL

Dr. CETRON. I would like to talk a little bit about the background and fill in a little bit on what Dr. Kranzberg said and go on from this, if I can.

I am pleased to be here. I think one of the main points brought up by both the committee and Mel is the point that, I think in a sense, the Russians, when they went into Afghanistan, tried to prove we were a paper tiger.

We were humiliated because we haven't been able to do much in the military area specifically. I am not here to talk about the military in general, but a lot of us felt constrained, if you will. That is one of the major reasons I believe Ronald Reagan and the conservatives got back into power and I think that is fine, except we expected from that—as an example, the Haley's Comet program, which is coming up in 1986.

It looks like the Russians want to be up there with a space program.

We will have to have some sort of a kite up there with a projector on it, if you will, to look at it ourselves.

The reason is our own space program specifically has not even considered going up there to take a close look at Haley's Comet.

No one is as qualified as we are to do it, and we aren't. If we are trying to get prestige and that is important for us, it would cost something like 25 cents, I believe, per family per year from now until 1986.

We have to get started if we are going to do it. But the prestige is not nearly as good as a manned program, if you will. This is an unmanned program.

If we are going for prestige, if we are looking to build ourselves up, that is an example that came to mind when you were talking.

I would like to talk a little bit about how we started in this R. & D. business, getting back to research and development in general and go to the space program, because really if we go back, just back to World War I—and I know a lot of us are not that old, but we should remember that prior to that, we were getting into the war.

President Wilson got a letter from the American Chemical Society saying, "We are right behind you when you get into the war. Any help you need, don't hesitate to call on us."

He wrote back and said, "Thank you very much, but I already have a chemical engineer working at Edgewood Arsenal."

I think things have changed a lot in the way of R. & D. If you look at what has happened since then, we can get a better feel for it.

R. & D. is ideas, invention, innovation and imitation. If the truth be known, from 1900 until 1930, we ran between fourth and sixth in numbers of Nobel prizes for science. Germany was ahead of us, England, France.

Sweden and the United States and Holland were tied for fourth through sixth place.

Things changed from 1930 to 1960. We did a lot better. We have more Nobel prizes than anybody else, which is really great except for one thing.

The language of science during that 1930 to 1960 time period was called broken English. It was those people who got out of Europe for political and religious reasons and came here to build up our scientific process.

From 1960 until now, we have won 66 Nobel prizes, far more than anybody else, more than three times more, which is great.

The problem very simply is that we are losing that lead.

I am skipping around through my testimony, but I will leave that here.

Basically there are three major industries coming up. The three largest growth industries in the United States and throughout the world, if you want to be brutally blunt. They end up being telecommunications and electronics. Second is robotization and the third is genetic engineering.

Those three are going to grow; 38 percent of our growth specifically in productivity in the United States is coming from the telecommunications and electronic industry.

Half that is robotization. We are being pushed into that. We can't control it. We can't control space, though we have a monopoly in that area. We haven't got it in robotization. We may start the program, but we will not be able to complete it and for a very, very good reason.

The Japanese Government in general and the German Government were told after World War II—and we told them in our infinite wisdom—"We are not going to let you work in research and development having to do with the military and we are not going to let you work in research and development having to do specifically with space."

We thought we would keep the leading edge ourselves. So all they could do was work in civilian research and development. They are doing very well in civilian R. & D.

I chaired the sessions for NATO on technology transfer in 1973 and 1975. We found out in the military program and in the bulk of the space program, with all due respect, numbers may vary, but only between 7 and 15 percent of the money in research and development is used for civilian purposes.

This means the great bulk of the money spent for military R. & D. and for space is not applicable. They are too expensive. This has to go through technical feasibility; cost effectiveness, social and political acceptability.

They do well in technical feasibility, but the military doesn't meet the enemy. The battle line is a balanced budget.

That is not its job. Thefore, the high technology can't be applied for many, many years.

Now, the reason I bring that up is because we do very, very well after the idea area, in invention, innovations, and diffusion. Extremely well.

It may be our hallmark. If we look—and you will see the figures in here on what we have done in inventions and innovations. We have done phenomenally well.

But the robotization is what I was getting to. The Japanese had no reason but to go robotic for the same reason we were talking about before, productivity.

Ninety-six percent of the energy is brought in now from outside. It will be 98 percent by 1990 and almost 99 percent by the year 2000.

In addition, they have no resources. Almost nil; 70 percent, the largest amount, the fourth largest trade in the world is betwen Australia and Japan to get the resources they need, the iron, the coal, the whole business in terms of resources.

Then they have a real big clump hitting them between 1985 and 1990. Fully 20 to 25 percent of their people retire at 80 percent of their base pay.

This seems, what you are talking about, to keep up productivity, is to go robotic. We have to go robotic in order to compete with them in terms of quality.

Some of the places robots will be used are hazardous environments. At the bottom of the ocean and, of course, in space. This is one of the reasons the spinoffs we are talking about in the space program will be a helpful area.

Genetic engineering. A lot of the work we would like to do specifically in the biological area, in the area of new types of pharmaceuticals and just plain getting a plain, ordinary round ballbearing, perfectly round, that is space.

Now if you are talking about getting an economic payoff—the bottom line, as Dr. Kranzberg brought up earlier, we are not going to get anything.

Very, very little up in the year 2000. But the point very simply is if we don't do our homework now, we are not going to be in a position to get that later on. That is what I am talking about.

I talked with a fellow called Dr. Sherman Gee, the head of R. & D. program at Du Pont. He said, "If I cut off my R. & D. now for the next 5 years, I will have the best balance sheet you ever saw. After that, we would go broke."

In reality, we are paying our dues and we are up to date now, we are really doing a job. We ought to follow through on it. That is part of what I wanted to talk about specifically.

Now the four highest areas in high technology happen to be: aerospace, heavy electronics, chemicals, and pharmaceuticals and that is it. Two of them are funded tremendously by the Government, electronics and aerospace. It goes through NASA, it goes through the military, and I think that is obvious to all of us working in the area.

The reason for chemicals and pharmaceuticals, they were big during World War I, if you will, and they are now mature industries.

They don't need the money from the Government. The other two do need it.

We get our tradeoffs, specifically, our aircraft, going to the civilian economy, that come from our programs with NASA and the military.

That is one of the big income-producing items for our balance of trade, aircraft. We have to keep up because we can't afford to lose in that area.

I have some figures to show that. You can take a look at that later on.

I would like to talk to the four principal objectives of the space program as I understand it. One is defense, the second is prestige, the third is knowledge, and the fourth is economic benefits.

And that is not in any specific order, but basically we started with Kennedy, with a prestige goal. We were embarrassed. Sputnik went up in 1957. We had to catch up.

If you want to be brutally blunt, we could have done even better before that had we used a Redstone missile instead of going for Vanguard, but we had to go automatic transmission with all the stuff we need in the Navy.

And I was working with the Navy at that time and I understand what we were trying to do, but the truth very simply is, you have to follow up because it is important for us there.

Let's talk in terms of military technology for a moment. Congressman Winn mentioned that his children know more about this, with the space programs we see today: "Star Wars," "Star Trek," and the whole business.

If the truth be known, what we have today in the military is better than the stuff we see in "Star Wars," today. "Star Wars" is one-on-one. You have a man out there picking up targets with a laser weapon or whatever he has out there, working with one weapon.

The truth is our weapons systems today—and it is in the public domain—can pick up 6 to 12 targets with the Phoenix missile system's lock-on. They can do what they want and push a button and knock off any one of the ones they want to.

That is much more sophisticated equipment, today, than we have in "Star Wars."

Second, of course, we are in a position right now where if a pilot got hurt, having the course, the speed, the check where he took off from, the plane would clear one of the channels, fly itself home and land itself with the wounded pilot, or the plane itself, to a predesignated place.

Things we are talking about in sophistication are far advanced. We haven't got a Stealth system yet up in space where they can't see what's going on.

So what we are talking about, then, is the major payoff being in the military area.

We are talking about laser weapons up in space, we are talking about pulse beam weapons up in space, we are talking about surveillance systems. The great big AWACS, if you will, up in space, looks at everything, not just lower level.

Now, my basic view—and my whole presentation goes around this, saying: Look: the aids-to-navigation program, taking the place of Loran NAVSAT, if you will, will do a tremendous amount in space. It will help all of us, civilian aircraft and the military as well.

I guess my basic pitch is, why can't we spend the money and have part of it transferred from the military Air Force program, transferred in for one, to bail us out because economically if someone is going to sit here and say, "I want to justify the space program, based on economic return," gentlemen, it is not there.

It really, honest to God, is not there. Now, if you want a time frame—someone was asking earlier—your timeframe is probably

20 to 50 years. That is why Johnson & Johnson is putting things into the Space Shuttle now to see what's going to happen in terms of pharmaceuticals.

That is why your corporations want to put up robotics into space to see how they will work out in space. But if someone doesn't fund the program, it won't be there to be used later on.

I could go through all the rationale for remote sensing and what we are doing in communities, what it looks like, and manufacturing and zero space gravity.

I don't think that is the answer. I think the answer really boils down to: Why aren't we going to be funding the program that is going to happen in the future?

Now, let me get back to real brass tacks. We know there is a budget-cutting procedure going on. We know that this generally happens.

At home, when things are tough and we haven't got money, we cut back our major expenses. We may hold off sending one of our children to college for a year or so.

We may have to work and get part of the money. We may hold off on buying an automobile or a house.

For a corporation, the first place it hits when you have a budget crunch is research and development, education and training and marketing, all of which have a long-term payoff.

I am positive that someone in budget cutting in OMB is going to say: This is education or this is going to be knowledge for the sake of knowledge and it is going to be research and development; therefore cut that.

I think we are making a big mistake because it is going to come off later on and we are going to really feel it at a later time downstream.

I have cut it pretty short. Some of the things are in the actual testimony itself, but I can take any questions you may have for at least a few minutes.

Thank you.

[The prepared statement Dr. Cetron follows:]

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STATEMENT

to

The Subcommittee on Space Science and Application

of

The Committee on Science and Technology
U.S. House of Representatives
Ninety-Seventh Congress

on

Future Space Programs

by

Marvin J. Cetron
President, Forecasting International, Ltd.

Monday, September 21st, 1981

The typical pattern of Research and Development in the United States has changed radically since the time of the inventor working independently in a laboratory in his own home. At the start of World War I, the American Chemical Society offered to help President Wilson in any areas of chemistry or chemical engineering, to which his response was "Thank you very much for the offer, but we already have a chemical engineer working at Edgewood Arsenal." In contrast, we now have a formalized team structure to attack almost all aspects of R&D.

The U.S. has not in the past always been a leader in Science and Technology, but rather an "early adaptor" of R&D performed typically in Europe. We have made progress in the "four Is": generation of breakthrough ideas, and application and development phases - invention, innovation and imitation (or diffusion) - and as recently as 5 years ago it appeared that the U.S. had achieved and was likely to retain the position of world leader.* However, we are now in the process of letting this advantage slip away.

Measures of international stature are difficult to quantify, but we can get a general idea in the realm of science by looking at indicators such as the citizenship of Nobel prize winners for Science. Table 1 shows the improvement in relative standing of the U.S. since the beginning of the century, moving up from fifth place prior to 1930, and subsequently maintaining a significant lead over other nations, until in the most recent list the U.S. has more than all others combined. This rather sudden acceleration may be attributed in part to the substantial influx of scientists who were educated abroad and migrated to the U.S. because of the political or religious turmoil of the 1930's. It is also a result of the great materials resources which are available in the U.S. The scientific areas where we lead are those which require expensive experimental equipment, which some nations cannot provide. (However, these are not necessarily areas which can be readily commercialized.) The United States although still one of the three leading nations, as it has been since 1930 -- certainly does not dominate.

In the realm of technology, the U.S. has been pre-eminent over a much longer period. Two crude measures of comparative standing are shown in Table 2. Column A indicates by nationality the number of authors of major inventions from Colonial times to the present day. Such a tabulation can be regarded as distorted both by chauvinism in the selection of responsible individuals, and lack of discrimination in the choice of inventions. The remaining columns show the average patenting rate in the 1930's and in 1975, for the countries listed. By either criterion, the U.S. was ahead of other nations; however, this position of leadership has been eroded over the last decade, as shown in Figures 1 & 2. In a recent report,** OECD states that except for the computer, aerospace, and heavy electronics industries, technology is primarily transferred into the United States from other countries. In the four high technology industries, aerospace, heavy electronics (including computers), chemicals and pharmaceuticals, the two areas where we lead are aerospace and electronics, where significant amounts of monies are funneled through government agencies by the Department of Defense, NASA, HEW, Department of Energy, etc. In the other two industries, chemistry and pharmaceuticals, since they are mature technological industries the bulk of their money comes from internal corporate funds or the stock market. This provides some indication that when the government funnels R&D money to private firms (as in electronics and aerospace), the industry prospers and we have a technological lead.

Technology and the U.S. Space Program

There are four principal objectives of the space program: 1) defense; 2) prestige; 3) knowledge; and 4) economic benefit. The military factor is now clearly the most powerful, although in the Kennedy era the prestige goal (e.g., putting a man on the moon before the Soviets) approached military objectives in terms of importance. The ranking of the other three factors varies along with national priorities.

Military Technology and Uses of Space

We are reaching the stage of development in military technology where real-life weapon systems equal or exceed in performance the gadgets depicted in such currently popular movies as Star Wars or Star Trek. For example, the Phoenix missile system can lock onto 6-12 separate targets simultaneously, identify each one as friend or foe and then destroy the correct ones. In contrast, even the spectactular weapons depicted in Star Wars could only deal with one target enemy at a time.

A similar level of sophistication is found in military uses of space and space technology. Surveillance satellites (Big Bird, etc.), for example, provide early warning of an enemy attack, verification of compliance with treaties, aids to navigation (NAVSAT), and data on our enemies' nuclear, chemical and biological weapons capabilities. Other potential application areas include orbital weapons such as laser and pulsed beam weapons.

Civilian Uses of Space

The four primary civilian uses of space and space technology are: 1) remote sensing; 2) communications; 3) manufacturing; and 4) acquiring knowledge. The exact order of importance is indeterminate, but the first two uses clearly rank above the other two. Remote sensing is essentially the application of surveillance satellites to civilian uses and can be used to perform such varied tasks as monitoring of air and water pollution, damage assessment, land and wildlife surveys, mapping, mineral exploration, and disaster prediction. Satellite communications, also a spinoff from the military sector, is rapidly expanding. Communication satellites have evolved from simply being a means to reach isolated places on the earth or an alternative to subocean cables. Today, they provide multiple-access facillities capable of carrying all types of signals (telephone, television, data) on a demand basis. Manufacturing in space is a promising civilian application (for example, zero gravity manufacturing). However, commercial feasibility is 20-50 years in the future. The final civilian use is in gaining knowledge for knowledge's sake, which is obviously the primary motivation behind the unmanned space program (Voyages, Pioneer Spacecraft).

Clearly, the R&D done by the U.S. military and space sectors is a leader, not only at home but abroad as well. However, the bulk of military and space R&D is not directly transferable to the civilian environment. Only 7-15% can be directly transferred.*** That fact is partially responsble for the United States losing its overall lead in technology, especially civilian technology.

Table 1

Nobel Prize Awards, by Country, 1901-1977

1901-1930		1931-1960		1961-1980	
Germany	27	United States	33	United States	66
England	15	England	18	England	23
France	11	Germany	14	Germany	7
Sweden	6	Switzerland	5	France	5
United States	6	Austria	4	Sweden	4
Holland	6	Sweden	2	USSR	4
Denmark	4	Italy	2	Austria	2
Austria	3	USSR	2	Belgium	2
				Denmark	2
				Argentina	1
				Australia	1
				Canada	1
				Italy	1
				Norway	1

Table 2

Selected Invention and Patent Rates, by Country[*]

	A Total Inventions on Selected List 1600-Present	B Average Annual Patenting Rate - 1930-1939	C[**] Annual Patenting Rate - 1975
United States	203	38,300	56,509
Great Britain	58	9,050	12,322
Germany	32	14,600	37,733[#]
France	29	9,550	13,386
Italy	14	3,900	--
Switzerland	--	3,130	4,369
Sweden	4	1,030	9,100[##]

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[*] Bode, H., Basic Research and National Goals, (Washington, D. C.: National Academy of Sciences, March 1965).

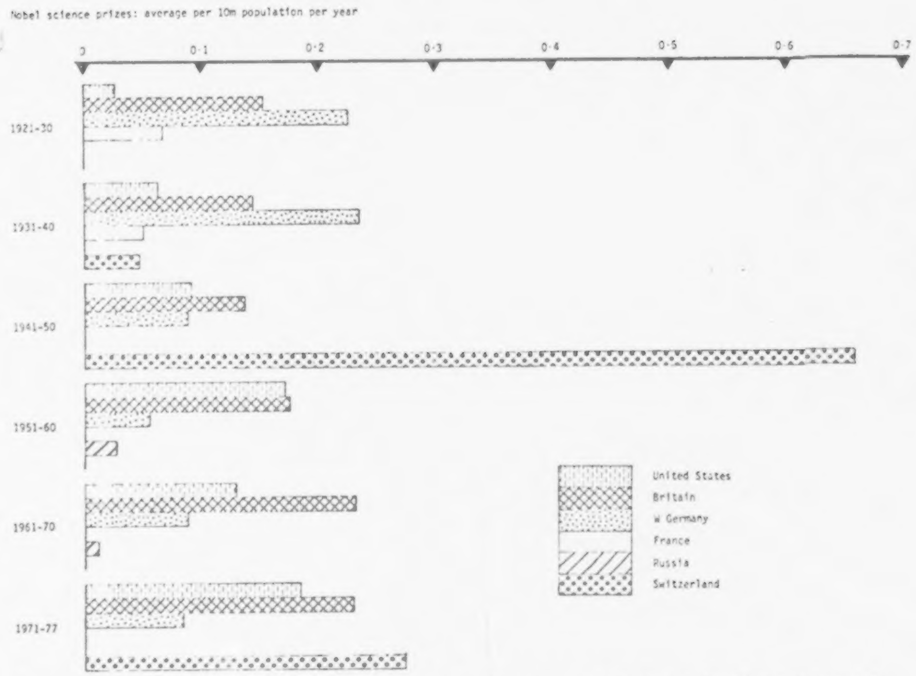
[**] Private Communication, U. S. Department of Commerce, Patent and Trademark Office, May 1978.

[#] West Germany only (FRG).

[##] This is made up of 7,233 foreign filings, and only 1867 by Swedish nationals.

Figure 1

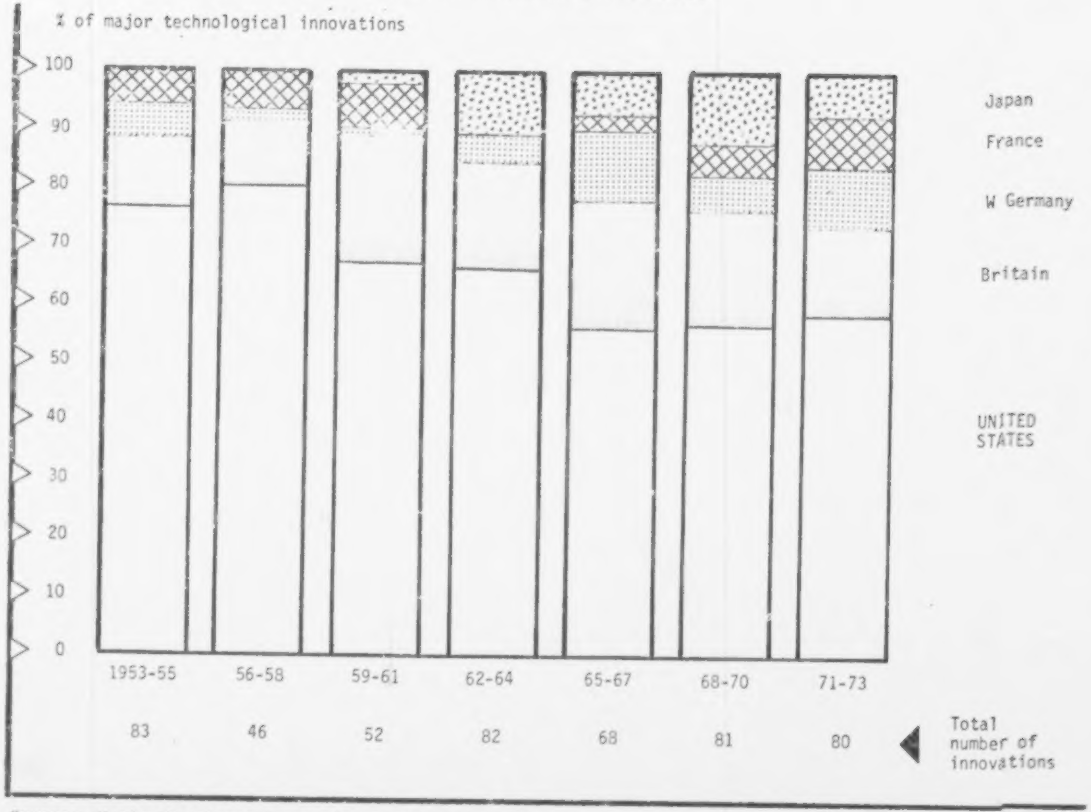
NOBEL SCIENCE PRIZES: AVERAGE PER 10 M POPULATION PER YEAR



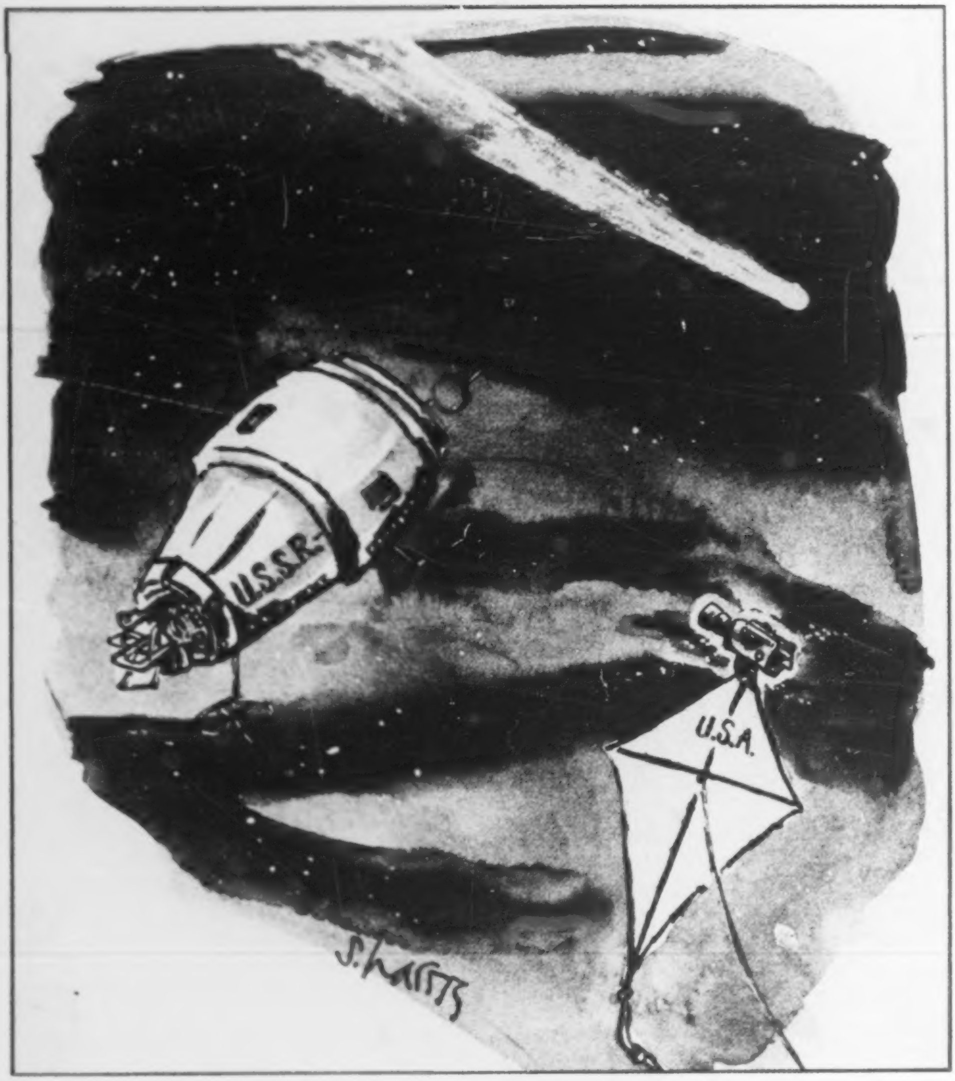
Source: National Science Foundation, Science Indicators, as depicted in "The Science of Olympics", Business Brief, The Economist, May 20, 1978, pp. 86, 87.

Figure 2

PERCENTAGE OF MAJOR TECHNICAL INNOVATIONS



Source: National Science Foundation Indicators, as depicted in "The Science Olympics", Business Brief, The Economist, May 20, 1978, pp. 86, 87.


U.S.S.R.
U.S.A.
S. Harris

Harris, S. "Skeptical Eye," Discover Vol. 2, No. 9 (September 1981), p. 10

At the end of the the Second World War defeated Japan and Germany were enjoined from engaging in military and space R&D. The U.S. thought that by imposing this barrier it could forestall potential competitors and maintain its technological lead. It was assumed that military and space R&D was the leading edge of technology and was directly transferable to the civilian sector. Pre-eminence in military and space technology was presumed to confer overall technological pre-eminence, witness the bombshell effect of Sputnik on the United States. Following that historic event, it was believed that the U.S. had fallen behind the Soviet Union technologically. Accordingly, enormous amounts of financial material resources were put into military and space R&D in order to overtake the Russians. Meanwhile, Germany and Japan were compelled to put all their R&D effort into civilian technologies such as automobiles and consumer goods. Today, the American technological lead in non-military applications has disappeared in all fields.

Why Continue the Space Program?

This question must be answered in terms of both a long-term and a short-term perspective. In the short-term (here meaning 0-20 years) economic return on the space program cannot be expected. It will not pay for itself, let alone yield a profit. Therefore, the principal reasons for continuing the space program in the short-run will be defense, prestige, and knowledge, with emphasis on the first. Military uses will continue to predominate, although in certain instances prestige may become very important, such as a possible visit to Halley's Comet when it reappears in 1986 (the U.S.S.R., Europe, and Japan all plan to send spacecraft to the comet; the U.S.

has not made such a commitment). However, in the long-term (here meaning over 20 years) the civilian space applications (e.g., manufacturing, mining) will increase the percentage of military technology which is directly transferable to the civilian economic sector. Therefore, significant benefits to the civilian economy will be derived from the space program in the long-run. At that time, the space program will begin to be self-supporting. However, in order to produce and exploit these technological breakthroughs, the United States must keep up its aerospace R&D which means continuing the space program. Thus, it is a long-term economic payoff that the space program promises, but a payoff that cannot be achieved without funding of R&D programs in the short-term.

In a corporation, when money becomes tight and budgets are slashed, the first areas designated for reduced funding are generally: 1) research and development; 2) education and training; and 3) marketing. Likewise, in the home, when money becomes tight, education expenses are pared back and long-term investments (e.g., car, house, etc.) are delayed. This cannot be allowed to happen with respect to the space program. Future economic success depends on maintaining R&D and education and training programs in the present.

Recommendation

The previous discussion clearly shows on the one hand that the military sector will receive the vast majority of the benefits accruing from the space program in the short-term. However, on the opposite hand the military devotes a share of funds to the space program disproportionate to the benefits which it receives. It is here recommended that this financing arrangement be amended to require the military to commit an amount of funds more proportionate to its benefits.

Footnotes

* Cetron, J.M., "Technology Transfer: Where We Stand Today"; Technology Transfer (Eds.; Davidson, Cetron ' Goldhir), NATO Advanced Study Institute Science; Noordhoff; (Leyden) 1974; pp. 1-28.

** Gaps in Technology, (Paris, France: Organization for Economic Cooperation and Development, 1970).

*** Consensus opinion of individuals who attended NATO Advanced Study Insitute on Technology Transfer. Evry, France, June 24 - July 6, 1973 and NATO Advanced Study Institute on Industrial Technology Transfer, Les Arcs-Bourg, St. Maurice, France, June 22 - July 4, 1975.

Mr. **Flippo**. Thank you very much for your testimony.

We read that members of the public don't appreciate the payoffs and spinoffs from NASA. Even some Government officials.

I read recently where some referred to the Shuttle as the turkey of the decade. Of course, there is an awful lot of competition for that designation. Projects and individuals, too. Do you consider the space program the turkey of the decade?

Dr. **Cetron**. I had an admiral I used to work for, the head of the Ordnance Corps in the Navy, 39 and 40 was saying, "That goddamn atomic weapon is for the birds. Why put a scientific thing out there that can't do a thing?"

Obviously some of the experts might not know what the nuclear weapons did during World War II.

We are not quite sure what the payoffs will be, because we can't enunciate them. Our hindsight is better than our foresight by a damn sight. We really can't sit back and say, "I know what it's going to be in the future," but we can get a pretty good indication of what's happening.

I don't think it is a turkey at all. I think it is a first step. So was Ford's Model T.

Mr. FLIPPO. I guess I am somewhat surprised at your statement that the bulk of military and space R. & D. is not directly transferrable to the civilian environment.

I believe you said only 7 to 15 percent can be directly transferred.

Dr. CETRON. That's correct.

Mr. FLIPPO. Do you have any suggestion as to how we might increase that percentage or are you saying that spin-offs are negligible?

Dr. CETRON. I don't think they are negligible. I am saying if we did more work, for instance—if we put more direct funding, for instance, into fusion. I am using an example. Trying to work through other sources.

I think the payoff becomes more direct, yes. But the country is rich enough to do both. I know that is a stupid thing to say, but the truth is we are not talking about that large amount we get in the payoff. It is like when we say: If a particular church took all the money they had from this and this, for the poor, and let them keep it, look how much—that would go like that and before you turned around, they would have nothing. I don't believe that is the answer.

I am saying in essence, yes, the work we do in nuclear, biological, chemical, and nonlethal weaponry, et cetera, in these programs, a tremendous amount will never be used in the civilian area.

A lot of the work we do specifically in surveillance would help, for instance, in the SALT talks and things like that for knowing what is going on.

We are not going to get much payoff in the near future. We will not get much payoff in some of the heavy materials used in tanks, light-weight titanium and things.

In the meantime, it does come in. We are using stuff, for example, aircraft technology for plastic automobiles, and by 1985, 50 percent of the automobiles by weight will be plastic and by 1990, 92 percent.

That beginning plastic work was done in the Navy and the Air Force, specifically the work being done on fuel cells will be used for propulsion plants.

A lot of it was submarine work.

Perhaps there is not a direct application but I don't think we can afford the luxury of forgetting it, either. That is why I think it has to go on.

Mr. FLIPPO. Doctor, your profession is looking into the future. How do you do it? What advice can you give us? Do you consult with industry and other governments?

Will Government participation become more or less necessary as we proceed?

Dr. CETRON. Let's go back to how we do it and what will be required. The way we do it is, we look at trend extrapolations and trend correlation and then we take a look at substitution models. You can see the substitution of water base paint for oil base paint. You can see the actual numbers.

You can see the substitution of bills for coins, checks for bills, credit cards and then finally a cashless society. You can get a plotting and actual dates for percentages.

These are easy to do. You can look at political and social stability in various countries. We have done that. But the indicators become more important.

For instance, everybody, OECD, World Bank, IMF, is looking at per-capita income as being an indicator. Really a better indicator is the bottom tenth of the population, what were they getting paid and how much times difference is this?

In Nordic countries, Sweden, Norway, Denmark, Finland, it is 2½ times.

The United States, 10 to 11. When it got to 38 in Iran—and it is not a lot different now, that is part of the problem they have. We have the same thing happening in Saudi Arabia. It is an indication of unstability.

Another indication—I will give you a couple so you can see what I am saying by indicators that you can take a look at.

Another indicator of stability happens to be the unemployment. But not unemployment that everybody is collecting—and that is what they are collecting, by the way.

The real guts I figure for unemployment ends up being—I don't mean to be chauvinistic, but it is the male population that is educated between 18 and 28 that is living in the city that is unemployed.

These guys give you fits. They haven't got a job, they haven't got a place to live. In the less-developed country, they can't even buy a wife in some cases and that is probably the group that took over the American hostages in Iran.

Another indication is not military budget, not numbers of tanks per miles of borders. If you want to know if a country is stable or not, see if they have doubled officers' salaries in less than 2 years. If the officer corps' salaries have doubled in less than 2 years, they are buying stability, they are buying loyalty of troops. You can see by looking at indicators that may well be different from the things you are saying.

In technology, you measure the pacing parameter. What measures it? What are you looking for? I think that is the thing we are trying to talk about here.

In space, we learn over time. I am inclined to believe, as it was said earlier, specifically Congressman Winn brought out that we have people now looking at what's wrong, what's trying to hold things back?

It is not technology assessment, it is technology harassment. "Stop it."

I think we made a mistake in trying to cut back, for instance, in genetic engineering, some of the things that are going on now, we will find ourselves blind also in the long run.

One of our strongest advantages is our disadvantage. In our strong advantages, we do everything up front. We let everybody know what we are doing, we publish it, we even structure it in the NTIS, the National Technical Information Service, we give it away to everybody.

We have key word, they know what to ask for. I think that is a mistake, in a sense. We are giving away, if you will, our basic signs and we are giving it away for nothing. The Russians have three copies of every single unclassified NTIS document that goes out.

I think we are giving things away. I know there is a public domain that should be available to everybody, but I think we are hurting ourselves there and, therefore, the capitalization becomes rough, especially when you start cutting back.

If we are going to have the bulk of our population—and I am talking about 11 percent of our population producing the hardware, by the year 2000, the rest of the 80 percent of us working in the service industries and the knowledge industries, and we are giving away the knowledge we are generating, then I think we are making a big mistake.

We should be doing this. We should be charging more, or not giving everything away.

Mr. FLIPPO. Thank you very much.

Mr. Winn.

Mr. WINN. Your last statement intrigues me. I sat in this same room last week with representatives from 11 countries, main Third World countries.

They were very smart, very smooth, very diplomatic, but basically they were saying, "We want the United States to be strong and continue to be a strong country," but at the same time, they want our technology.

This is a real problem. The group of 77 through the United Nations and some of the other organizations are really pushing that now and we have a great many people in the United States that are saying that is exactly what we should do.

That if we are going to get along with the developing nations or the Third World countries, then we have got to share our technology with them.

Then how far do we go in sharing that technology, until they just cut us off at the pass by developing something better than we can, or have? Like the Japanese. That is a good example.

Dr. CETRON. It took them 20 years to do it, but they did it very effectively.

Mr. WINN. From a history standpoint, 20 years is really not very long.

Dr. CETRON. You know it. That is only 2000. Not even that. I think the answer is we have to make a better decision on what we give away and don't give away.

The Japanese are not going into the robotic industry to produce their automobiles and their own things. They are exporting now, since February, I think, 100 robots per month.

They expect that to be their largest growth industry, and export them throughout the world. We are doing some consulting work for a very, very large firm in the United States right now. They are thinking about spending $1 billion before 1990 to get into the same market.

I think it is the best market to get into.

But the technology they are using to build on is ours. This is what I am saying. I think we are undercutting ourselves.

I am not saying we shouldn't give away a lot of things. I think we should charge more for it and I think we ought to get ourselves in a position of taking a better look at—have a national strategy, if you will, for research and development.

We haven't got one right now.

Mr. WINN. Is that your opinion that the robotics industry is a spinoff of the space program?

Dr. CETRON. I think it is partially there because they had to do a lot of things out in a hazardous environment. It is not completely, but it is a major one.

Mr. WINN. Would you call Voyager II a robot?

Dr. CETRON. No, I wouldn't. I would say it helps us in a lot of telecommunications, telefleetering electronics, but it is not a robot, per se.

Mr. WINN. Do you think very many people have any idea of the tie between the use of the regular civilian space program and the military space program?

Dr. CETRON. No, I don't think they have a full appreciation for it, I really don't.

Mr. WINN. I have an awful feeling that a great many Members of Congress don't really thoroughly understand that. One reason that they may or may not support the space program is because they don't know how much of the military program is involved.

They are either for it or against it. Luckily, so far we have had the majority of the Members of Congress support the space program. Some of them were afraid if they voted against the space program, they might be voting against part of our military program.

Dr. CETRON. Look, let's be brutally blunt, gentlemen. The services, the miliary have been getting a free ride for a long time. They are buying at the margin. I think what should be done, especially if they are not going to cut the military budget that greatly, I should think a large proportion of that should be used because—there is an old joke when I was still back in the service.

I got out in 1971. I spent 20 years there as a civilian in the R. & D. lab. They talked about the Navy having two types of ships. They have submarines and they have targets. All that happened because of the space program.

The truth be known, without a space program, they wouldn't have that kind of a problem. The space program and the military applications of space is going to be crucial in the future.

Cutting back any place over here would be a very, very big mistake. I think the military should be picking up a larger share of it.

Mr. WINN. A few of us agree, but there are also those who feel if the military picks up the larger share, they are going to want to have more to say about the control of the program and then the scientific community gets unhappy.

Dr. CETRON. Let them be a little unhappy.

Mr. WINN. Well, they are all unhappy now.

Thank you very much.

Thank you, Mr. Chairman.

Mr. FLIPPO. Mr. Hollenbeck.

Mr. HOLLENBECK. Along that same line, how do you feel at the bottom line, should civil and military space programs interface? Should we have a necessarily separate military program, as the chairman stated in his opening remarks? Should we have a distinctly civil program?

Dr. CETRON. It may sound like it is funded separately from two separate pockets, but in reality, it is mixed already. We can't kid ourselves. They are very much in bed with each other and they have got to be. We can't separate these two things.

I am just saying somebody else should be paying a larger share. That is what I am really saying. That is a lot more.

You can't separate it. It can't be done.

Mr. FLIPPO. Thank you very much, Doctor, for your testimony. I hope you are not late for your appointment. You presented very helpful information.

Our final witness today is Mr. Dennis Little, a specialist in Futures Research and Population Policy at the Congressional Research Service, Library of Congress.

As a demographer, he studies how population trends affect the economy and other areas of life. For example, his most recent article, "Profiles of America," discusses the 1980 census that reveals changes in how Americans live and how social institutions such as utilities and others will serve them.

We want to see how these trends will affect or be affected by our space program.

We are very pleased to have you with us today, Mr. Little. Please feel free to proceed as you deem appropriate.

[A biographical sketch of Mr. Little follows:]

DENNIS L. LITTLE

Biographical Sketch

Dennis L. Little has attended Georgetown University, Wayne State University, and the University of Southern California and holds degrees in government and public administration. Upon graduating from Georgetown in 1962, he entered Ford Motor Company's Graduate Training Program in Dearborn, Michigan, where he worked in purchasing, administration, and the product development office. In 1968, the Metropolitan Fund (a Detroit based urban affairs foundation) asked Ford Motor if Little could be granted a one year leave of absence to work on some regional intergovernmental programs for the fund. Upon completion of this assignment Little resigned from the Metropolitan Fund and from Ford and joined the staff of the newly created Institute for the Future in Connecticut. As a research associate at the institute, he worked on simulations, models, selected urban problems, the relationship of business to society, and a wide variety of futures oriented sociological problems. Little entered public service in 1972 when he was appointed Commissioner of Income Maintenance, the Department of Public Welfare, Commonwealth of Pennsylvania. His position was the highest ranking career position in the department. With the transfer of the administration of income maintenance programs for the aged, blind, and disabled to the Federal Government, Little transferred to the Long Range Planning staff of the Social Security Administration. He then transferred from the Executive Branch to the Legislative where he established and directed the Futures Research Group of the Congressional Research Service (CRS), Library of Congress. He now serves as a

Specialist in Futures Research and Population Policy and as Executive Secretary of CRS' Foresight team. Little has taught for the College of Social Studies, Wesleyan University; the Department of Sociology, the University of Hartford; the FELS Institute, the University of Pennsylvania; the School of Public Administration, University of Southern California; and the Policy Studies Program of the University of Maryland, Baltimore County. He has served as a consultant on various futures projects such as: International City Manager's Association (Urban 2000), Midwest Research Institute (Kansas City Tomorrow), National Institute of Public Administration (President's Management Intern Program), United States Department of Agriculture (Renewable Natural Resources), and Edison Electric Institute (Future of Economic Growth). A frequent contributor for professional journals, Little is active in the World Future Society, an elected member to the U.S. Association to the Club of Rome, the American Society for Public Administration, and is an elected board member of the National Educational Institute for Economic Development. He is former Chairman of ASPA's Public Service Futures Committee. His book, Managing Renewable Natural Resources: A Handbook for the '80s will be published in December 1981.

STATEMENT OF DENNIS LITTLE, SPECIALIST IN FUTURES RESEARCH AND POPULATION POLICY, SCIENCE POLICY DIVISION, LIBRARY OF CONGRESS

Mr. LITTLE. Thank you, Mr. Chairman, and Mr. Winn.

My remarks today will be slightly different than the previous two speakers, as the chairman pointed out.

I am a social scientist, with the job title designated specialist in futures research and population policy.

My knowledge of the space program is limited and we have other people inside of CRS; Barbara Luxemborg, Marcia Smith, who are in the audience who are CRS' subject area experts in this area.

My task today, as I understand it, is to relate to you some of the environment in which the space program will operate in the next 10 to 30 years. In doing so, I have concentrated on demographic trends, both global and domestic and their intersection with public policy questions that are of interest to the Congress and to this committee in particular. I find the chairman's opening remarks, and my own remarks overlapping. As you will note on the first page I turned to Peter Drucker, the management consultant who pointed out long range planning does not deal with future decisions but with the futurity of present decision and of course that is something that the Space Committee has to concentrate on, how their decisions of today will influence the space program 10, 15, 20 years on out.

Starting with the global population patterns it took until about 1800, 1850 for this globe to have 1 billion people. It was not until

1930 that we had 2 billion people. By 1975 we had 4 billion. And within about the next 20 years somewhere around the year 2000 we will have 6 billion people and the UN projections indicate that roughly around the year 2100, 2110 there can be—based on present statistics for that type of thing—we will stabilize at 10.5 billion people.

These are astronomical increases. The distribution of these population increases over the next 20 years will not be uniform or evenly distributed. We will see the population doubling in Africa in about 24 years and I think if you look on page 5 or 6 of my testimony you will see in Europe it is doubling every 178 years or thereabouts.

The importance of these increases can be ascertained in terms of the global carrying capacity [the biological life system that supports the Earth], the international labor market, third world urban growth and the access of the United States to strategic minerals and metals that are important to the industrial production of the United States.

In terms of the global carrying capacity we know that the Council on Environmental Quality recently issued the Global 2000 Report and although people might take issue with the exact numbers and the directions that they pointed, they are the best numbers that the government has available.

In terms of things like forests we find out that back in 1950, 25 percent of this Earth was covered by forests. In 1979 that number had dropped to 20 percent. By the year 2000 it is estimated to be around 16.5 percent [that is a continuation of current trends], and by the year 2020, 14 percent.

In terms of agriculture, the population of the world will increase by 50 percent in the next 20 years—give or take several million people. That means essentially that agricultural production will have to increase by 50 percent just to keep up with where we are. That raises the question of whether or not we will be able to get the agricultural scientists required to meet this demand to produce the needed food, train them, get them out there in the system, but also it raises the question if it took 12,000 years for us to reach our current level of agricultural production, can we increase that by 50 percent in the next 20 years. The basic question that it raises to me as a social scientist, unfamiliar with the space program, is how much might space technology be used to expand agricultural and timber production within the biological carrying capacity of the United States.

Will we have an adequate pool of engineers to both supply the engineering base for the renewable natural resource systems that we apparently are turning to and to meet the demands of robotics, the reindustrialization, the electronics as well as that of the space program.

Moving on quickly to the question of the labor force. Based on current population directions and the fact that the labor force is easier to determine, because most of it is already known as to what it will be like 20 years from now, the labor force globally will increase by almost 1 billion persons, 900 million, with most of that growth being within the Third World.

The number of jobs that will have to be created within the Third World in, by the year 2000 are equivalent by rough estimates to the number of jobs already in the industrialized world currently. Put in slightly different terms, the number of jobs required will be growing at a rate of 50 million a year on a global basis whereas back in the 1900's they were growing at the rate of approximately 50 million a decade.

The basic question this time on a global scale. Will space programs promote employment and in what manner or form, or will they preclude funding of basic social welfare programs? I don't have any real answer to this question and as you know, CRS does not take positions on these types of questions.

In terms of the Third World urban cities in 1900 there were no cities of 5 million—only one city—of 5 million or more. By 1970 there were seven cities. By 1980, today, roughly, there are 26 cities of 5 million or more, the majority in the Third World.

According to U.N. estimates by the year 2000 there will be 60 cities of 5 million or more; 46 of these will be in developing countries and 18 of them will have populations of better than 10 million individuals.

According to former World Bank President Robert McNamara, the cost just to house those people in adequate—he did not define the word "adequate," that is always open to question—runs in the neighborhood of $215 billion in 1980 dollars. This might not be out of the ordinary because in the estimates given for the physical requirements of New York City over this next two decades the number is around $40 billion.

The question these trends raise to me is will the urbanization of the third world create a great deal of unrest, tinderbox situations for the United States? Will the capital needed to repair the central cities and to build the cities that will be required to handle that sized population, along with other competing demands, preclude adequate capital being available for the Space Program.

In terms of strategic minerals and metals, we import only 42 percent of our oil requirements. By contrast last year, we imported 19 minerals and metals that were deemed to be essential to the industrial production of the United States with an import ratio of 50 percent or more.

We imported 93 percent of our cobalt requirements, used in approximately 85 percent of our domestic, commercial jet engines and also used in some of our military planes. We import very high percentages of cobalt, chromium, and platinum. These metals are essential to converting crude oil to gasoline and to our telecommunications industry. They are imported from African nations that are experiencing growth rates where their populations are doubling every 24 years. Their central cities are doubling every 12 years. Their slums are doubling every 5 to 7 years and it creates the question of the stability of the access to that material.

The question in my mind is what contribution could remote sensing play to locating different sources for these minerals perhaps within more stable countries perhaps in other geographic locations. And if remote sensing is not the answer, mining in space, is that an answer, and what type of time frame is attached to it.

If you turn quickly to the domestic side of the question, we see that we are facing an aging population. That is not news to anybody but the percentage of the population over 65 has risen from 4 percent in 1900 to 8 percent in 1950, to 11 percent roughly today and depending on death and birth statistics you might use around 2029 or 2030—it gets out to 17 to 22 percent. Such things as life expectancy could extend that out further. You have the situation of kids with kids, with an ever-increasing number of teenage pregnancies. The details of that are enumerated in my paper.

You also have the changing ethnicity of the U.S. population. If one looks at the legal immigration statistics and sees the country of origin over the last 20 years, it has shifted rapidly from Europe to Southeast Asia, Latin America, and Mexico. Census statistics reveal that the Hispanic population within the United States has risen since first enumerated in 1970, from something like 9 million-plus to 12 million-plus to over 14 million-plus in the 1980 census. At the rate it is going, one sees it is possible by the year 2000, 2020 that a very large percentage of our population will be descendants of the immigrants that have entered the United States in the 1970's and later decades.

Now, what that means is we are experiencing a sharp shift in our age structure. We are getting a larger number of people that will see no immediate benefits from the space program and that is apt to continue.

We are seeing changes in our family structure where we have a decline in family size and a rise in the number of childless families. The payoff is not there for Johnny and Susie and according to one recent Harvard-MIT joint center for urban studies project. According to this study, it is conceivable that by 1990, two-thirds of all households in the United States will be without children.

This is a sharp shift in the traditional value structure and sharp shift in demographic patterns.

When you see also the rise in single-parent families, which we see no expectation to change drastically, that also has tremendous impact on our school systems. Studies done by the Kettering Foundation and others have shown that these children simply do not produce as well inside of a traditional school system as those from the two-parent family. This raises the question to me of their general ability to concentrate and develop in the scientific and mathematical fields.

In summary, Mr. Chairman—and I have tried to go over this rather quickly—I hope that it has been coherent—it seems to me that the global population patterns and the question that they raise raises opportunities for the space program to contribute to their solution.

The domestic population patterns of the next two decades raise the high probability that there will be an ever-increasing number of different interest groups competing for what free funds might be available for the space program or anything else.

I thank you very much for having had the opportunity to testify and hope that my testimony has contributed to the committee's effort. I am available for any questions you might have.

[The prepared statement of Mr. Little follows:]

Congressional Research Service
The Library of Congress

Washington, D.C. 20540

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STATEMENT OF DENNIS L. LITTLE
SPECIALIST IN FUTURES RESEARCH AND POPULATION POLICY
SCIENCE POLICY RESEARCH DIVISION

Before the

SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS
COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

INTRODUCTION .

Mr. Chairman and Members of the subcommittee, my name is Dennis Little. I am a specialist in Futures Research and Population Policy at the Congressional Research Service (CRS) of the Library of Congress where I also serve as executive director of CRS' interdisciplinary Foresight Team. During the last six years my research and writing efforts in support of Congress have focused on the development of futures information and analysis, emerging issues, demographic and social change, and in assisting this committee and others in implementing the House foresight provision.

The effort of the committee to relate the space programs to future conditions on earth, and the efforts of other committees in the House to assess the future environment in which their legislative programs will be operating, are clear signs of increasing congressional interest in understanding the long term consequences of today's decisions. As Peter Drucker notes, "Long range planning does not deal with future decisions, but with the futurity of present decisions." This current effort appears to complement nicely the committee report, Survey of Science and Technology Issues Present and Future (June, 1981), and builds upon the earlier 1975 and 1978 hearings on future space programs.

In my remarks I have focused on describing global and domestic population trends and forecasts and their intersection with selected policy areas of interest to Congress. The forecasts shown are not definitive statements of the future, but merely plausible future contexts within which the consequences of present actions may occur. In general the forecasts deal with conditions on Earth 20 years from now. In some cases the time frame has been extended to 50 years and in other cases it may be as brief as a decade. In most cases after the discussion of the major demographic trend, I have attempted to provide potential links to the space program by identifying issues or opportunities or by raising questions. Admittedly as a population expert and not a space policy expert, for there are others in CRS with the latter credentials, some of these sections are rather sparse. However, this demographic and social backdrop should allow those more closely involved in the space program to provide the more detailed linkage.

GLOBAL POPULATION PATTERNS

> As I have pointed out elsewhere, short of nuclear war itself, it (population) is the gravest issue the world faces over the decades immediately ahead.
>
> Robert S. McNamara
> President of the World Bank

Population growth and its consequences have been a concern of the scholar for over 200 years. What's new in the population growth debate is the relatively recent rapid rate of population growth. As table I indicates it took more than 10,000 years and perhaps as much as a million years for global population to reach one billion persons around 1800 A.D. Another 100 years was required to reach the second billion; only 30 additional years were required to reach a third billion; and just 15 more years to reach the fourth billion.

TABLE I. Global Population 1/

Year	Population
8000-6000 B.C.	Below 10 million
1 A.D.	133-400 million
1650	460-475 million
1750	800 million
1800-1850	1 billion
1930	2 billion
1960	3 billion
1975	4 billion
1987	5 billion
1998	6 billion

1/ Van der Tak, Jean, Carl Haub, and Elaine Murphy. Our population Predicament: A New Look. Population Reference Bureau. v. 34, no. 5, Dec. 1979. p. 3-4; and Organization for Economic Cooperation and Development. Midway Through Interfutures. July 1977. Population figures for 1987 and 1998 are estimates based on 1979 rates of population growth.

If the present tempo of population growth is maintained, the United Nations' medium-range estimates indicate that world population would stabilize at approximately 10.5 billion persons in the year 2110. 2/

Currently the global population is estimated at 4.5 million persons with the Population Reference Bureau estimating the population to be increasing at the rate of 144 persons a minute; 1.5 million a week; and 75.7 million persons a year. 2/ These are of course no more than best estimates, for no one knows with certainty the exact size of the population of the world at any one time. The collection and reporting mechanisms in the developing countries, the current home of approximately 70 percent of the world's population, are irregular and unreliable. Even the United States, with a comparatively sophisticated system, reportedly missed five million people in the 1970 census, and found almost five million they hadn't anticipated in 1980.

The rate of population growth between 1980 and 2000 will not be uniform, but will vary by region and continent. Table II depicts the projected population growth ranges by regions and continents. The rate of natural increase and the time for doubling the population by continent ranges from 0.4 percent (178 years) in Europe to 2.9 percent (24 years) in Africa.

2/ Salas, Rafael M. The State of the World Population, 1981. United Nations Fund for Population Activities, 1981.

3/ Haub, Carl. Population Data Sheet. Population Reference Bureau. Apr. 1981.

TABLE II. POPULATION GROWTH PATTERNS BY REGION

Region	Mid-1981 Pop. (Millions)	Rate of Natural Increase	Years to Double Pop. [4]	Year 2000 Pop. (Millions)	% Pop. Under 15	Urban Pop. %	Per Capita GNP [5]
World	4,492	1.7	41	6,095	35	41	$ 2,340
More Developed	1,144	0.6	114	1,255	24	71	7,260
Less Developed	3,348	2.1	34	4,840	39	30	560
Africa	486	2.9	24	833	45	28	620
Asia	2,608	1.8	39	3,564	37	28	800
North America	254	0.7	95	286	23	74	10,710
Latin America	366	2.3	30	562	40	63	1,580
Europe	486	0.4	178	511	23	71	6,820

Source: Haub, Carl. Population Data Sheet. Population Reference Bureau.
Apr. 1981.

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[4] At current growth rates.

[5] In U.S. dollars.

The projected population increases of the next 20 years coupled with those of the past 20 years will place great strains on the carrying capacity of the earth's natural biological systems; the international labor market; Third World urban growth; U.S. access to strategic minerals and metals essential to the industrial production of the United States; and could create "tinderbox" situations in Third World countries which are deemed important to U.S. national security interests. The next sections of this paper touch briefly upon most of these areas.

GLOBAL CARRYING CAPACITY

Although fragmentary, incomplete, and perhaps questionable, the data indicate that overfishing, overgrazing, and deforestation have become widespread as changes in consumer taste coupled with record population increases have caused shocks in the carrying capacity of biological systems in many parts of the world. The Global 2000 report to the President released in the summer of 1980 concluded, "If present trends continue, the world in 2000 will be more crowded, more polluted, less stable ecologically, and more vulnerable to disruption than the world we live in now." 6/ Twenty-five years ago forests covered approximately 25 percent of the world's land surface; in 1979 they covered 20 percent, by the year 2000, based on present trends, it will fall to 16 1/2 percent, and by 2020 to 14 percent. 7/ In the early 1970s one hectare of land (2.47 acres) supported an

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6/ Council on Environmental Quality and U.S. Department of State. The Global 2000 Report to the President. v. 1. Washington, U.S. Govt. Print. Off., 1980. p. 1.

7/ Brown, Lester. President of Worldwatch, Inc.

average of 2.6 persons in the world. By the year 2000 the same amount of land will have to support four persons. 8/

If population growth continues at approximately the same level it did in 1975, our current global population will double by approximately 2015, and consequently food production must double over approximately the same period. Food production has kept pace with past growth but it has taken a 12,000 year period to reach the current levels of production. It will take more and better trained agricultural scientists; and significant increases in the private and public sector to meet these goals. 9/ While some estimates indicate that the world water supply can be expected to handle requirements through the end of this century the Global 2000 report indicates that periods of spot shortages will become more and more frequent. About 80 gallons of water per day are required to maintain a family at the present level of usage in an industrialized country and the minimum in the Third World is about nine gallons per day. 10/

These trends raise a number of policy questions which are linked directly or indirectly to decisions regarding national space policy. Some of these include: assuming a continuation of existing technology, are the biological

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8/ Population Reference Bureau. The Global 2000 Report and Implications for the United States (Summary of hearings conducted by Subcommittee on Census and Population, Committee on Post Office and Civil Service, U.S. House of Representatives, May 12, 1981.)

9/ Borlaug, Norman E., R. Glenn Anderson, and Ernest W. Sprague. The Human Population Monster, 1980.

10/ Estimates provided by Carl Haub, Research Demographer, the Population Reference Bureau.

systems of the globe approaching their maximum carrying capacity? Governmental programs to limit reproduction raise many, seemingly impossible to resolve, value and ethical issues. Would space colonization contribute to the solution of the problem? If so, is space colonization an acceptable answer? Is it technologically feasible? Can our science education programs provide the needed agricultural scientists as well as the scientists necessary to develop the next space programs? How might existing or new space technology be used to expand agricultural and timber production within the biological carrying capacity?

THE INTERNATIONAL LABOR MARKET

Since labor force growth is largely determined by population growth, one can forecast with reasonable accuracy, the size of the labor force in the year 2000. Table III reflects labor force growth from 1950 to 1975 and the projected

TABLE III. Increase In World Labor Force, With Projections To 2000

Region	1950-1975	1975-2000
	(millions)	
Developed	123	118
Developing	423	782
World Total	546	900

Source: Cited in Newland, Kathleen. Global Employment and Economic Justice: The Policy Challenge. Worldwatch Paper No. 28, Apr. 1979.

growth for 1975 to the year 2000. On an annual basis the world's labor force is growing by approximately 50 million workers a year -- compared to 50 million a decade in the early 1900s. Approximately 600-700 million new jobs will be needed in the developing countries in the next 20 years and this is more than all the employment available in 1980 in all of the industrialized countries. They will be joining a labor force in 1978 which had approximately 50 million unemployed and 300 million more who were underemployed. One forecast estimates that registered global unemployment will reach the 100 million mark by 1990. 11/ The challenge of finding work for almost one billion jobseekers by the year 2000 is enormous. Would a continued strong space program serve as an employment stimulant or would it preclude adequate funding of selected social welfare programs?

THIRD WORLD URBAN GROWTH

The Third World is experiencing an explosion in the growth of its large cities. In general the populations of developing countries are doubling every 25 to 30 years; their large cities are doubling every 10 to 15 years, and the urban slums and shantytowns in these cities every 5 to 7 years. Currently,

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11/ Population Crisis Committee. Labor Force Growth Unemployment and Migration. Population Briefing Paper No. 7. Sept. 1977. Teitelbaum, Michael. Testimony before the Subcommittee on International Economic Policy Committee on Foreign Relations. U.S. Senate. Feb. 27, 1981; and Newland Kathleen, Global Employment and Economic Justice: The Policy Challenge.

approximately half of the residents of these large urban centers do not have adequate access to minimal nutrition, clean water, health facilities, primary education, public transport, and other public services. 12/

Cities of five million or more did not exist until about 1900 when London reached that size. By 1950 there were seven cities of five million or more inhabitants with two being in the developing countries. Today there are 26 cities of five million or more and United Nations forecasts that in the year 2000 there will be 60 cities of five million or more and 46 of these will be in developing countries, with 18 having populations of better than ten million. Cities of 25 or 30 million are well beyond the realm of existing human experience. The speed at which such massive additions will occur seems likely to present severe planning problems, problems of implementation; and severe capital constraints. Robert S. McNamara places the investment cost at $215 billion (in current prices) over the next 20 years just to supply decent shelter to all poor urban families by the end of the century. 13/ In New York City alone, it is estimated that more than $40 billion must be invested during the next decade to repair, service, and rebuild basic public works facilities. 14/

12/ McNamara, Robert S. An Address to the Board of Governors, (World Bank). Belgrade, Oct. 2, 1979. p. 12-13.

13/ McNamara, Robert S. An Address to the Board of Governors; Newland, Kathleen. City Limits: Emerging Constraints on Urban Growth. Worldwatch Paper No. 38, Aug. 1980. p. 7; Fox Robert W. Latin America: New Realities. Geopolitics of Energy, v. 2, no. 12, Dec. 1980. p. 6.

14/ Choate, Pat and Susan Walter. American Ruins: Beyond the Public Works Barrel. Council of State Planning Agencies, 1981. p. 2-3.

Will the capital requirements for public works and housing of the large global cities be one of a series of competing demands from various sectors which would preclude the availability of public and/or private funds for the continual development of our nation's space program? While the new urban centers offer new economic markets, will their sheer size and lack of amenities force the multi-national corporation to establish smaller administrative units in these countries than they might otherwise? If so, would they substitute satellite communications for face to face contact?

ACCESS TO STRATEGIC MINERALS AND METALS

While many policymakers and citizens are concerned about the continual dependency of the United States upon foreign oil, many of these same individuals are not aware of the increasing dependency of the United States upon foreign sources for non-energy mineral commodities considered to be strategic to the economy and the military capability of the United States. During 1980, according to the Bureau of Mines, the United States imported 19 minerals and metals with import-consumption ratios of 50 percent or more, and for ten of those materials the ratio was 90 percent or higher. 15/ Of this group the strategic and critical metals are extremely important. Our country imported 91 percent of its chromium requirements, 88 percent of its platinum-group metals, 93 percent of its cobalt, and 97 percent of its tantalum and manganese. Over 80 percent of the commercial aircraft of the United States are powered by the TT8D jet engine which contains 900 pounds of cobalt. Military aircraft like the F-15s and the F-16s also require 900 pounds of cobalt. Platinum is used in the process of converting crude oil into gasoline and in the manufacturing of catalytic converters. Based on today's technology, there would be little high octane gasoline, no catalytic emission control for combustion-engine cars, and a primative oil refining industry without platinum. Paladium, one of the platinum groups metals, is essential for coating telephone contact points and therefore is important

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15/ Calingaert, Michael. U.S. Mineral Maneuvers Must be Global in Scope. American Metal Market. May, 1981. p. 38.

to the whole telecommunications industry. Manganese is essential to the production of steel. 16/

Rapid population growth in the Third World could create an instability within many mineral rich Third World nations. Table IV examines the past and projected population increases for those countries supplying only the minerals and metals mentioned above. The countries have been arranged in descending order of magnitude according to the estimated percentage of population increase between 1980-2000. The table raises at least two questions. First, might sharp increases in population create instability within the rapidly growing countries and in turn result in a shutdown of supplies to the United States? Second, will population growth in neighboring countries (not reflected in the table) be so great that intercountry instability occurs and supplies are cut off or reduced? For example, Kenya borders on Zimbabwe which is rich in minerals. In 1980 Kenya's population grew by four percent and its economy by only two percent. It is probable that Kenya will have to import food for the rest of the decade. If the current population growth rate continues, the number of school children will double by the year 2000 and the economy will have to generate 560,000 new jobs a year (double the 1980 level of 260,000). 17/

16/ Warshofsky, Fred. Strategic Minerals: The Invisible War. Reader's Digest, Feb. 1981. Miller, James Arnold, Daniel I. Fine and R. Daniel McMichael. The Resource War in 3-D: Dependency, Diplomacy, Defense. World Affairs Council of Pittsburgh 18th World Affairs Forum, p. 5; and James Daniel. Our Alarming Vulnerability to Minerals Mischief. Washington Star, Mar. 3, 1981.

17/ Ross, Jay. Kenya's four percent Birthrate Said to Create "Mind Boggling" Problems. The Washington Post. June 20, 1980, p. A-15.

TABLE IV. World Population Estimates 18/

Country	Material Exported to U.S.	Population (millions)			Increase in Population	
		1960	1980	2000	1960-1980	1980-2000
Zimbabwe	chromium	3.6	7.4	14.0	106%	89%
Zambia	cobalt	3.2	5.6	10.4	75%	86%
Brazil	tantalum, manganese	71.5	126.4	212.5	77%	68%
Philippines	chromium	27.6	51.0	83.4	85%	64%
Zaire	cobalt	17.7	28.3	46.4	60%	64%
Rep. of S. Africa	chromium, manganese platinum	17.3	29.3	47.8	69%	63%
Thailand	tantalum	26.4	47.7	76.1	81%	60%
Turkey	chromium	27.5	45.3	69.4	65%	53%
Malaysia	tantalum	7.9	13.6	20.2	72%	49%
Gabon	manganese	.472	.551	.752	17%	36%
Australia	manganese	10.3	14.5	17.8	41%	23%
Canada	platinum, tantalum	17.9	24.1	29.0	35%	20%
U.S.S.R.	chromium, platinum	214.3	266.7	311.9	24%	17%
Finland	cobalt	4.43	4.82	5.11	9%	6%

18/ Selected Demographic Indicators by Country, 1950-2000; Demographic estimates and projections as assessed in 1978 Department of International Economic and Social Affairs. United Nations, New York, 1980.

All of this must take place in a country which has a 1980 per capita income of $380 in 1980 (in 1980 per capita income was over $10,000 in the U.S.) 19/

One could also suggest, on the other hand, that rapid increase in population might bring even greater pressures on the mineral exporting countries to protect and expand their minerals exporting position in order to create needed jobs and increase export revenues. Similar pressures to control internal unrest by maintaining employment levels and maximizing export revenues have been major factors contributing to the lack of success of past cartel attempts (other than oil) to increase prices through controlled production.

One assumes continual random disturbances in the Third World during the next two decades. Would remote sensing from space make resources easier to find? If not, or if not in sufficient quantities could the needed resources be mined in space? At what financial, environment, and potential cost?

19/ Population Reference Bureau, 1981 World Population Data Sheet of the Population Reference Bureau, Inc. 1981.

POPULATION PATTERNS IN THE UNITED STATES

Moving from global demographic changes to changes within the United States, it is clear that during the last two decades, significant demographic changes have occurred and have caused the profile of America to change. These might be described as follows:

- For 11 straight years (1954-1965), during the baby boom, births in the United States exceeded four million;
- During the 1970s birthrates have remained below natural replacement rates;
  - current rate is 1.8 births per woman of childbearing age while the replacement rate is 2.1.
- With the declining birth rate, immigration (legal and illegal) plays a great role in structuring the ethnicity, culture, and values of our society;
  - the emphasis in immigration patterns to the United States has shifted from Western Europe to Latin America and Asia.
- A significant increase in the number of "kids with kids" (teenage pregnancies);
- An increasing proportion of the population over 60 and this proportion is expected to continue to increase;
  - median age has moved over 30.
- Changes in family structure, composition, and life style;
  - later marriages and fewer children,
  - a higher divorce rate and a sharp rise in one-parent families.
  - by 1990 two-thirds of all households may be without children.
- A continual increase in the number of women entering the work force (mainly married women);
  - from 1947 to 1978 female participation in the labor force increased by 15 million,
  - from 1979 to 1990 an additional 11 million increase is forecasted.
- A slight reduction from the 1960 rate of central city outmigration;

- A concentration of central city outmigration among young families in the $15,000-to$25,000 income range;
- Gains in population in the Sunbelt's central cities (primarily due to annexation) but a decline in some cities with populations of one million or more;
- Northeastern and North Central central cities losing population, with the metropolitan areas, in general, showing increases;
- A slight increase in the overall rate of interregional migration;
- A reversal in the traditional black outmigration from the South; and
- Rural areas outpacing cities in rates of population growth.

In the sections which follow some of these trends and their possible future directions will be discussed in greater depth.

SOME GENERAL POPULATION TRENDS

In terms of specific numbers, the April 1980 Census found that our nation's total population had increased to 226,504,825 people for an 11.4 percent (23 million plus) increase over the 1970 level. This is the lowest rate of growth for a decade since the Great Depression and the Census Bureau expects even lower rates of growth in this decade--less than ten percent and slowing to less than seven percent in the 1990s. 20/ Projected population growth: 1980-2000 is shown by region in table V.

20/ Levine, Daniel. Demographic Trends Shaping the Nation. Remarks before the Demographic Outlook Conference, Ithaca, New York, Jun. 9, 1981.

Natural population growth adds approximately 1.6 million to the population each year and legal immigration adds an additional 25 percent to the natural growth. Although the exact number of illegal immigrants is unknown the range is estimated by the Census Bureau at three to six million. Demographers Leon Bouvier of the Population Reference Bureau and Michael Titelbaum of the Ford Foundation believe that illegal immigration accounts for an additional 15 to 25 percent of the annual U.S. population growth. With that trend in mind, the composition of growth, immigration, and the distribution of the population in the United States becomes increasingly important. A few thoughts on the first two items are appropriate at this time.

TABLE V. Projected Population Growth: 1980-2000*

REGION/STATE		GROWTH
PACIFIC		22-25%
Washington		
California		
Oregon		
MOUNTAIN		28-37%
Montana	Colorado	
Idaho	Arizona	
Wyoming	New Mexico	
Nevada	Utah	
WEST SOUTH CENTRAL		22-25%
Texas	Arkansas	
Oklahoma	Louisiana	
WEST NORTH CENTRAL		11%
North Dakota	Minnesota	
South Dakota	Iowa	
Nebraska	Missouri	
Kansas		

* Includes only continental United States

TABLE V. (Cont.)

REGION/STATE	GROWTH
EAST NORTH CENTRAL Wisconsin Illinois Indiana Ohio Michigan	7-12%
EAST SOUTH CENTRAL Mississippi Alabama Tennessee Kentucky	14-18%
SOUTH ATLANTIC Maryland Delaware District of Columbia West Virginia Virginia North Carolina South Carolina Georgia Florida	26-31%
MIDDLE ATLANTIC Pennsylvania New Jersey New York	4-7%
NEW ENGLAND Maine Vermont New Hampshire Massachusetts Connecticut Rhode Island	15-16%

Source: Calculated from U.S. Bureau of the Census. Current Population Reports. Series P-25, No. 796. Range shown is for assumption II-A and II-B.

A Shift in the Age Structure

The aging of the baby boom children coupled with a declining birth rate will have a large impact on the relative size of future population age groups. Table VI indicates the distribution shift that would occur in the following scenario: the current birthrate will continue into the the mid-1980s, rise to one percent as the number of women of childbearing age increases, and fall to 0.6 percent in the early 1990s as a declining number of women enter childbearing age.

TABLE VI. Age Distribution of Population, 1970-1995
(Percent in Each Age Group)

Age	1970	1977	1985	1995
15 and under	30.2	25.7	23.9	24.0
16-24	15.7	16.9	14.8	12.1
25-34	12.6	15.6	17.3	15.4
35-44	11.4	10.9	13.5	16.0
45-64	20.4	20.1	18.9	20.2
65 and over	9.7	10.8	11.6	12.3

Source: Institute for the Future. Policy Choices in Vocational Education. Menlo Park, Institute for the Future (Report 48-A), December, 1979, and 1979 Census estimates.

There already has been a decline in the young age group (ages 15 and under), and a decline in the labor force growth rate is forecast because of the decline in the relative size of the 16 to 24 age group.

The earlier increase in the 16 to 24 age population during the 1970s from 17.1 million to 24.3 million persons is one reason for the rise in unemployment rates. Teenagers who have significantly higher unemployment rates than other workers, are expected to decline in numbers by approximately eight percent during the next decade to 22 million with an additional nine percent decline to 20 million during the 1990s. As a result, a scarcity of lesser skilled and entry level employees could develop.

The changing age structure of the United States also may have a direct, positive effect on labor productivity. One factor thought to have depressed the rate of productivity during the past decade has been the huge influx of relatively inexperienced women and young people into the work force. As women gain more experience, the proportion of inexperienced workers in the labor force is likely to decline, and productivity may increase.

Kids with Kids

Almost 17 percent of all births in the United States are to teenage mothers, and in 1977 approximately 44 percent of these births occurred outside of marriage. By contrast, teenagers in 1950 bore only 12 percent of all children. If present rates continue, approximately 20 percent of today's teenage women will become pregnant while of schoolage. These births are significant because of their total economic cost to the public sector, and because of its impact upon the vision and understanding of the teenage mother. 21/

It is estimated that during 1979 over 1,000,000 teenagers (for the fifth straight year) became pregnant with approximately 600,000 of them giving birth. In 1976 teenage abortions accounted for 32 percent of the nation's abortions. The 600,000 annual births according to a Stanford Research Institute study could cost the Federal, State, and local governments a maximum of $8 billion a year in welfare and medical costs. An Urban Institute study estimates the costs

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21/ Moore, Kristin. Teenage Motherhood: Social and Economic Consequences. Washington, D.C., The Urban Institute, Spring 1980, 50 p. and The Games Teenagers Play. Newsweek, Sept. 1980. pp. 48-53.

for a single year at $4.65 billion. The difference between the two cost estimates is largely due to methodology. 22/

According to studies conducted by Johns Hopkins University, for this particular group--teenage mothers--the social problems are manifold. There are higher risks of death and medical complications; suicide and child abuse are higher than among older groups; approximately eight out of ten young mothers drop out of high school; and existing day care centers offer little immediate assistance because more than three fourths of all day care centers in the United States refuse babies under two years of age.

Immigration

Another source of new people is immigration--legal and illegal. As noted earlier, legal immigration accounts for about 25 percent of the annual population increases, and illegal immigration may account for as much as 10 to 25 percent more.

In examining our nation's profile, immigration is important in terms of the absolute number of people entering the United States and in terms of their country of origin. The United States has set carefully defined limits on the number of aliens it admits legally and with the decline in our nations's birth rate, immigration has become a highly visible public policy issue.

Unrest in Southeast Asia, the Cuban exodus, a rapidly growing Mexican population, and relative economic prosperity in Western Europe are just a few of

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22/ Children Having Children: The Cost to Government is Large. Across the Board. The Conference Board, v. 16. July 1970, pp. 7-10.

The Urban Institute estimates are for one year. The Stanford Research Institute's estimates are based on supporting the mother's children through the age of 18.

the factors that account for the shift in immigration country of origin patterns during the past 10 to 15 years. Since 1965, immigration from Asia and Mexico has risen dramatically, while Europe's share has dropped dramatically, as shown in table VII.

TABLE VII. Distribution of Admissions 23/

	1965	1977
Oceania	0.5%	0.9%
Africa	1.1%	2.2%
Asia	7.0%	34.1%
South America	10.4%	7.1%
Europe	38.2%	15.1%
North America	42.7%	40.5%
Total	100.0%	100.0%
(Total Number)	(296,657)	(462,315)

Hispanic Factor

Hispanic immigration and the higher birth rate for Hispanics already in the United States are the main reasons this country is the sixth largest Spanish speaking nation in the world, with 14.6 million (6.4 percent) as of the April 1980 census. Hispanics comprise more than one-third of New Mexico's population, one-fifth of Texas' and almost one-fifth of California's, and Hispanics outnumber Blacks in 18 States. 24/

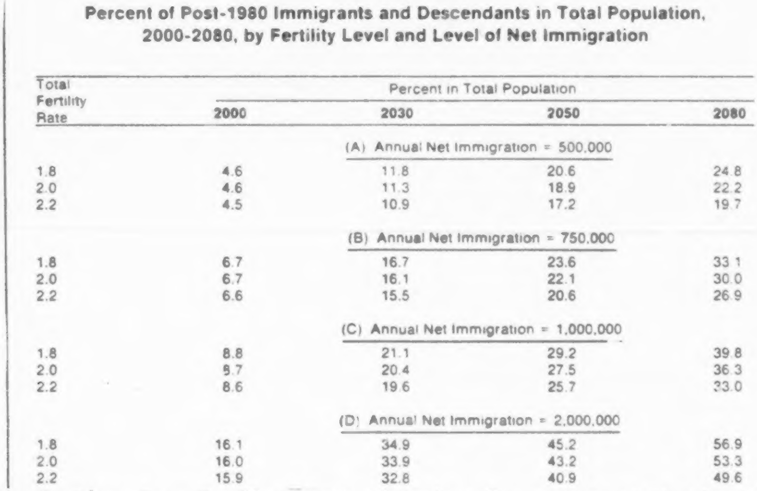
23/ Kraly, Ellen Percy. Limits in the Land of the Free. American Demographics, v. 2, no. 3, Mar. 1980. p. 18.

24/ Some of the increase shown in the 1980 census is statistical and not real, for in the 1970 census some four million Hispanics were enumerated as White. This change will also result in a statistical drop in the number of Whites.

The probability of a continued large increase in the Hispanic population, however, is reasonably high. Several researchers estimated Latin America's population will double in 25 years from 300 million in 1977 to approximately 600 million. Mexico's doubled in 20 years, going from 32 million to 64 million between 1958 and 1978. It is expected to double again by 1998, around the same time Central America's population will double and reach approximately 39 million inhabitants. 25/

If current immigration patterns continue and the birth rate inside of the United States does not change, 100 years from now (2080) approximately 40 percent of the population will consist of post-1980 immigrants and their descendants. This is shown in table VIII.

TABLE VIII



Percent of Post-1980 Immigrants and Descendants in Total Population, 2000-2080, by Fertility Level and Level of Net Immigration

Total Fertility Rate	Percent in Total Population			
	2000	**2030**	**2050**	**2080**
		(A) Annual Net Immigration = 500,000		
1.8	4.6	11.8	20.6	24.8
2.0	4.6	11.3	18.9	22.2
2.2	4.5	10.9	17.2	19.7
		(B) Annual Net Immigration = 750,000		
1.8	6.7	16.7	23.6	33.1
2.0	6.7	16.1	22.1	30.0
2.2	6.6	15.5	20.6	26.9
		(C) Annual Net Immigration = 1,000,000		
1.8	8.8	21.1	29.2	39.8
2.0	8.7	20.4	27.5	36.3
2.2	8.6	19.6	25.7	33.0
		(D) Annual Net Immigration = 2,000,000		
1.8	16.1	34.9	45.2	56.9
2.0	16.0	33.9	43.2	53.3
2.2	15.9	32.8	40.9	49.6

Source: Bouvier, Leon F. The Impact of Immigration on U.S. Population Size. Population Reference Bureau, Inc. Jan. 1981.

25/ Anson, Roberto. Hispanics in the United States: Yesterday, Today, and Tomorrow. The Futurist, v. XIV, 170. Aug. 4, 1980, pp. 27 and 29; and American Council of Life Insurance. Social Research Services. Data Track 5, p. 30.

Our Aging Population

Everyday in the United States, about 5,000 persons celebrate their 65th birthday, and about 3,400 persons 65 or older die. Since 1900, the percentage of individuals in the United States over 65 has increased steadily. In 1900, individuals older than 65 comprised 4 percent of the total population. By 1950, this figure had doubled to 8 percent,, and by 1980, it was approximately 11 percent. The 65-plus population of the United States is currently growing twice as fast as the general population. To give some idea of the numbers, the elderly population of the United States in 1979 was greater than the total populations of several countries, such as Canada (23. 5), Australia (14.2 million), Belgium (9.8 million) and all of Scandanavia (22.2 million.)

TABLE IX. PERSONS 65 AND OVER

Year	Number (in millions)	Percent of Population	Over 75 as a Percent of 65 and Over
1900	3,099	4.1	---
1930	6,705	5.4	---
1960	16,675	9.2	33.7
1977	23,431	10.8	36.8
1990	29,824	12.7	39.4
2000	3[illegible]822	12.9	44.1
2010	34,837	13.9	41.8

Source: Miscellaneous Census publications released prior to the availability of 1980 Census. Assumes existing rate of mortality and a birth rate of 2.1 births per woman of childbearing age.

The increasing number of elderly also will put pressure on our existing health care delivery systems. In turn, this will drive up the costs of the fringe benefit programs offered by most employers unless changes are made in health care systems. Statistics show that the aging constituted approximately

10.8 percent of the total population in 1977, but in that year, they used approximately 29 percent of all health care resources. Statistics indicate that 20 percent of all those over 65 are admitted to a hospital in a given year and almost 25 percent receive at least one outpatient service a year.

Former Secretary of Health, Education, and Welfare Wilbur Cohen has speculated that unless there is some significant reduction in the utilization or cost of health and medical services by the aged in the next 50 years, about half of all personal health expenditures might be expended on the aged. Total costs of health and medical services might represent 12 to 15 percent of the GNP as compared with 8.6 percent in 1976. 26/

Life Expectancy

Life expectancy tables and expected advances in technology lead to one belief that there will be an increasing female majority among the population over 65. The key is what shifts, if any, will occur between 1980 and the year 2000?

Specifically, estimates show that by the year 2000, there will be 150 women for every 100 men, and widows will outnumber widowers by six to one. At the same time, approximately ten percent of our older Americans will be either

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26/ Joint Economic Committee, United States Congress. Statement of Mayer Zald. Professor of Sociology, University of Michigan (Washington) May 31, 1978. Testimony at hearings before the Special Study on Economic Change and Stanley J. Brody, The Thirty-to-One Paradox: Health Needs of the Aged and Medical Solutions. National Journal, Nov. 3, 1979, p. 1869. Based on 1975 per capita health expenditures ($212 for persons under 19, $472 for persons 19 to 64, and $1,360 for persons age 65 and over).

single, never married, widowed or divorced, and increase of 100 percent compared with 1975. 27/

Because of their better education and increased social and political awareness, the senior citizens of the year 2000 may have less tolerance for today's kind of custodial care in all of its aspects, including the use of rest homes. They are more likely to be financially secure through more beneficial economic resources, such as improved pensions and social security, better comprehensive medical care and increased preparation for and participation in retirement.

This improved security and personal role satisfaction could lead to the increased popularity of leisure village and communities designed for our senior citizens. We may see fewer extreme cases of disorder behavior (i.e., those which require custodial care.), and by the year 2000 we might expect 25 to 35 years of retirement. This may create new sociological divisions, such as "young-old," ages 65 to 80, and "old-old," ages 80 and over.

The questions of aging and life extension, coupled with a declining birthrate, raise some major policy questions, which require greater exploration. Some of these include:

1. Who will support the aged and how will this support be financed?

27/ Unless otherwise noted the remainder of this section adapted from the author's early work. U.S. Library of Congress, Congressional Research Service. Some Past Trends and Future Demographic Projections for the United States, by Cynthia Huston and Dennis L. Little (Washington) 1977, pp. 10-12. (Report No. 77-162 SP)

2. How will increasing average ages affect the rate of change in society?

3. Should our tax laws be revised to make it less costly or even profitable for the extended family to stay together (i.e., a personal income tax deduction of $5,000 for each individual over 65 living in your home)?

4. How will aging affect education, crime, mobility, family formation, self respect, and public perception of science and technology?

5. Will new federally financed services be required (e.g., retirement counseling)?

Since the late 1960s, one policy issue has been social needs v. space. Will the demographic patterns of the 1970s and 80s (a declining birthrate, an aging population, and an increasing number of teenage pregnancies) lead to an exacerbation of this issue? How will the immigrant population affect the space program?

THE NEW FAMILY

Although traditional family values may be under pressure, the family is still basically nuclear with new nuclear forms emerging such as two wage earners, delayed births and fractured but nuclear.

By 1990, this situation could change considerably. If one assumes the current low fertility pattern continues through the decade, as many as half the women born during the mid-1950s will be childless or with only one child. As a result a declining proportion of all households will have young children present. According to one 1980 projection, by the Joint Center for Urban

Studies (Harvard University and Massachusetts Institute of Technology), only half of all married couples (50 million) will have children under the age of 15 living at home by 1990. If one adds this figure to the projected 20 million female-headed households without children, the calculation comes to almost 60 million households without children or almost two-thirds of the projected total number of 1990 households.

Working Women

The increased participation by women in the labor force has been termed a subtle revolution, and statistical data appears to support this. From 1947 to 1978, working women increased by 18 percent, but never by more than 1.5 percent in any one year. During this period of time, approximately 15 million women were added to the labor force, bring the total to 42 million.

Most forecast indicate this trend will continue. According to the Urban Institute report, one million additional women will enter the labor force each year between 1979 and 1990, a total increase of 11 million. Bureau of Labor Statistics reports project female labor force participation rates in 1990 from 54 percent (low growth) to 60 percent (high growth). Factors supporting a continuation of the female worker trend include: 28/

28/ Smith, Ralph E. The Subtle Revolution: Women at Work. Washington, Urban Institute 1979, and Women Work and Family: Between Myth and Reality, Center Focus, Issue 42, Mar. 1981, p. 1; and American Council of Life Insurance. The Changing Nature of Work. TAP 17. (Washington), 1978, p. 3.

1. A rising number of families have become accustomed to or require two incomes.
2. Women's higher education creates higher expectations about the jobs they seek.
3. More children and young people are learning to accept to propriety of women working outside the home.
4. The increasing number of white collar service industry and part-time jobs will attract more women.
5. Increased work experience will lead to increased rewards such as higher wages, promotion opportunities and seniority rights.

Of the 11 million women entering the work force between 1979 and 1990, 3.1 million are expected to be mothers with children under six, a 56 percent increase over the 1978 level, and 5.5 million are expected to be mothers with children between the ages of six and 17.

The sheer numbers raise questions as to whether changes in work schedules will be required to enable working mothers and/or two-wage earner families to juggle the demands of children and jobs. Changes may also be required in child-care programs. These are two social issues the public and private sector will need to face as the nation's new profile evolves.

CONCLUDING OBSERVATIONS

The Presidential Commission for a National Agenda for the Eighties noted, "Over the last generation, a number of remarkable demographic and social trends have greatly altered the contours of what we often think 'as traditional American life.' An awareness of these trends and their implications are essential if we are to establish rational, coherent, and relevant long-term policies for the eighties." The demographic and social trends and forecasts developed in my testimony appear to say two things. First, that space technology may be one possible instrument or contribution to the resolution of the myriad of global population, agricultural, and environmental problems which will be encountered during the next two decades. Second, changes in the demographic profile of the population of the United States (a declining birthrate, "kids with kids," an aging population, and changes in immigration patterns) will increase the competition for public funds which might be available for public space programs.

Mr. Chairman, I hope my comments have been helpful to the subcommittee, and I will be please to try to answer any questions the Members may have. Thank you for the opportunity of testifying before you today.

Mr. Flippo. Thank you very much.

Your testimony has been stimulating. We appreciate it very much. It seems that technology seems to be barely keeping ahead of demography. Even when demography explodes it seems to stay ahead. Why wasn't Malthus right? How can we continue to stay a little ahead? More specifically how do you think the space program can react back on demography? That is, what makes people decide to have more or less children, get more or less education?

Mr. Little. I don't know if I really know the answer but those are a series of individual questions that individual couples make individually and collectively that affect the direction of the Nation. The birth rate fell during the 1930's. The birth rate during depressions, wars, et cetera, is affected by individual choice. It seems we are moving out of a direction that the 1970's have been termed—the decade of the "me" generation.

Yankelovich's new book, "New Rules," indicates that people now not only want a choice, but they want to consider the idea of large families, two, three, four, five or more children as basically an option they have the right to enjoy; that they have the right to go back to basic values should they so desire and peer pressures and other things should not push them into no children, one child, or whatever it may be.

I really don't know, to be honest with you. I think in my own mind that the United States has always been a colonizing nation. During the thirties when you couldn't expand westward further we went to economic expansion to the West and I would think as we look for economic solutions there will be the possibility of colonization.

But whether or not it will be 100 years, 200 years, I don't know. Those are out of my baliwick.

Mr. Flippo. Would you care to comment that the nation that recognizes its natural resources and manages them best will have the best chance of meeting the needs of those future population changes?

Mr. LITTLE. I think that is unquestionable. I think you asked Dr. Cetron a question about people looking at certain things such as the Shuttle as the turkey of the decade or whatever, I would not be at liberty to give any awards anyway due to the rules we operate on but it reminded me of the theorem that if I cannot solve the problem, the problem is unsolvable—a very narrow perspective.

I suspect that some of the people who view the space program or any science program, if they cannot solve and understand what it is attempting to do, therefore the problem is unsolvable in that respect.

Mr. FLIPPO. Mr. Winn.

Mr. WINN. Thank you, Mr. Chairman.

Mr. Little, it is my understanding that you have written on how the United States might be affected by population trends in the Third World countries through the mechanisms of the U.S. dependency on these Third World nations for critical materials.

You have touched on it just a little bit in your opening remarks. I wonder if you could give us a little more specific information on what you are talking about.

Mr. LITTLE. Yes. Back in 1979 and more recently we did papers for Senator Mathias which were then released by Senator Mathias which were on Third World population trends and U.S. material dependency. We looked at our import ratios for these strategic minerals and metals as designated by the Department of the Interior and found out that we were importing 50 percent or more of 18, 19, 21 minerals, depending on whose count it was.

Then we looked at the country of origin that they came from, availability from other sources, suitability, and found out that when you looked at the country of origin and then you linked them up with their population growth, 1950 to 1975, these countries were experiencing growth rates of 80 to 160 percent.

And then when you laid it out for 1975 to the year 2000 based on U.N. projections or other available projections, although the population curves went down, they were still expected to experience growth. Instead of 80 to 160 maybe it was 60 to 120. This led me to raise the question with some of our people who work in that area, as to the stability of those countries as being continual sources of supplies for critical minerals and metals. Then it seemed to settle down that there were about five metals that were most essential to the industrial production that were affected by numerous factors but population was clearly one of them.

Mr. WINN. Along that same line then, if we wanted to read boogeyman books—and I think we have to from time to time—I see the possibility with these Third World countries having a great many minerals and ore that we need—probably most of the people in the United States just are not aware of that either—with the population increasing, thereby the demand for those products is increasing, it could well come down to the survival of the fittest which means the United States, Russia, and I don't know who else in the next 20 or 30 or 40 years.

Now the Polish Government is having trouble with their population because of the economy and the lack of food. Those two things probably turn people into tigers, fighters, militant terrorists, whatever they might be, faster than anything else.

That is a people problem. The People's Republic of China has the biggest people problem that I am aware of. Hand to hand they probably could not do much battle with the Russians on their border if they had to but they would throw literally billions of people into that battle.

Their economy is bad. It looks to me like the world is fast and quickly developing a people problem and all the problems that go with people problems.

Mr. LITTLE. People make problems. But people also solve them.

Mr. WINN. You mentioned African countries. They don't want to listen to some of our missionaries on birth control and some of the suggestions that are made to those countries along with lots of other people, that would somewhat help the economy if there were fewer people.

You say you are not a space expert.

Mr. LITTLE. Definitely not.

Mr. WINN. We have to then try on the committee to develop programs and fund programs that are going to benefit one, the people in the United States, the taxpayers who are paying for it.

Second, the people in the world that have products, minerals, ore, that we need to help the people in the United States survive and the people of the world.

I don't mean to sound like just the United States but actually we don't have many votes outside of the United States.

Mr. LITTLE. Your point is very clear, Congressman Winn. My task today, within the rules of the legislature which allows CRS people to testify, was to be primarily descriptive.

We are really not allowed, even if we had recommendations to make, to make those, because we are not here as advocates but to describe that external environment.

Mr. WINN. But you are waving a big flag. You are waving a flag to us showing us we have real, real people problems coming up and they are based on the figures you have quoted there, they are here really. They are here.

Mr. LITTLE. Yes.

Mr. WINN. In the space progams that I know of that are coming up I don't see anything that we are doing that will really take care of those problems. We better take another look. Maybe NASA had better help us take another look too.

We will have them up here. We will ask them a lot of questions too.

Mr. LITTLE. I don't have the things in front of me but on minerals and metals essential to industrial production of the United States, there are additional R. & D. directions that one could take that are outside of the purview of the subcommittee but within the purview of the entire Science and Technology Committee and some of those are identified I mentioned earlier, although I must admit at this hour I cannot flip them off like that but I would be glad to send the committee staff copy of the paper.

Mr. WINN. I think the committee would appreciate your furnishing us any information of that type because we are now at a stage—we don't have a foreign aid bill now. I am also on the Foreign Affairs Committee. We don't have a foreign aid bill before this Congress. We don't have enough support by the Members of

Congress or by the people of the United States, more than the Members of Congress, to pass a foreign aid bill.

Still a lot of those minerals that you are referring to are by countries that are asking us for foreign aid, needed badly, and some where they are going to say forget whatever the mineral or the ore is that we need from those countries, if we can't help them somewhat.

Mr. LITTLE. With your permission I will forward that to the committee.

Mr. FLIPPO. We will be pleased to have that. Mr. Hollenbeck.

Mr. HOLLENBECK. I have no questions.

Mr. FLIPPO. Mr. Little, our real problem that we have and that many committees have is that we have those who say, well, why don't we just spend all of our money on meeting these human problems that people have. This problem of communication and explaining why we have to have a bigger pie, that technology is the key to having that bigger pie to serve more of those needs is awfully important and your testimony will help us in that regard. We thank you very much for being with us today.

We will stand in recess until tomorrow morning at 9:30 in this room again and I think we will have some exciting testimony tomorrow. Carl Sagan and others will be here and we will invite you all back again.

Thank you for being with us.

[Whereupon at 3:35 p.m. the subcommittee adjourned to reconvene the following day at 9:30 a.m.]

FUTURE SPACE PROGRAMS: 1981

TUESDAY, SEPTEMBER 22, 1981

House of Representatives,
Committee on Science and Technology,
Subcommittee on Space Science and Applications,
Washington, D.C.

The subcommittee met, pursuant to call, at 9:30 a.m., in room 2318, Rayburn House Office Building, Hon. Ronnie G. Flippo (chairman of the subcommittee) presiding.

Mr. Flippo. The subcommittee will come to order.

Today, we will continue our hearings on future space programs with two sessions, one this morning, one this afternoon. This morning's session has been titled "How the Next Generation of Space Program Might Come to Pass."

The first witness that we will have today will be David Hannah, president of Space Services. We will want to come back to that. First, I would like to recognize the ranking minority member for a statement at this time.

Mr. Hollenbeck.

Mr. Hollenbeck. Thank you, Mr. Chairman.

If I might take a few minutes before I ask for your leave to attend another hearing from which I will return. Yesterday, we heard from three witnesses, a historian, a demographer and a futurist. Today, we will hear from people who represent the next generation. These are people who I believe will give us some insight into the possibility of grassroot support for the civilian space program and its various special interest projects.

We will also learn about a privately owned company producing expendable launch vehicles that may compete with existing launch vehicles. I hear all the time from constituents who express interest in the space program. However, their support is nominal. What we need to know on this subcommittee is this: How much support is there for our civilian space program?

We have a strong military space program and, as Dr. Cetron said yesterday, the military and civilian space programs are interconnected. In order to share costs and save various space projects, should the military now run the civilian space program?

The time seems to be ripe for a privately owned and operated expendable launch vehicle company in the light of the current administration policy to reduce Government spending. How will Space Services Inc. compete with existing launch vehicles, in costs, reliability and services? What can we do in Congress to encourage the activities of companies like Space Services, or do existing regulations and international laws make their activities virtually impossible?

In this afternoon's session we will hear from those people who have profited from spinoff technology. In yesterday's hearing several witnesses told us Space Shuttle spinoffs will not be realized until after the year 2000. It is difficult for a private company to invest in a technology where a profit will not be seen for some 20 years. Should the Government continue to have strong technology utilization and technology transfer programs that will fund these future spinoffs? Or do we force industry to carry this long-term financial burden for potential spinoffs?

I look forward to the testimony from our witnesses today to give this subcommittee some insight into our role in future space programs.

Mr. **Flippo**. Thank you very much.

Mr. Nelson.

Mr. **Nelson**. Mr. Chairman, I regret that I am unable to attend this morning's meeting of the subcommittee due to a direct conflict with a meeting of the full Budget Committee to take testimony from the Secretary of Defense, Caspar Weinberger.

Mr. **Flippo**. The gentleman from Texas, Mr. Hall.

Mr. **Hall**. Thank you, Mr. Chairman, I have no statement.

Mr. **Flippo**. Mr. Hannah, if you would come to the witness table, please.

Mr. David Hannah is the president of Space Services, Inc., and he is building a rocket with all private funding which he hopes will compete with NASA for the business of launching satellites. He has some good ideas on what needs to be done to bring the private sector more fully into our space programs, as a leader, not merely as a contractor to Government.

We look forward to having your testimony. We will accept your full statement for the record. Please feel free to summarize as you see fit.

STATEMENT OF DAVID HANNAH, JR., PRESIDENT, SPACE SERVICES, INC.

Mr. **Hannah**. Thank you very much, Mr. Chairman. I appreciate the opportunity to appear before you and the committee.

I would like to begin, if I could, by telling you a little bit about my background and how I got involved in space development. I am a native Houstonian, and I have a sailboat down at Clear Lake, which is on the other side of the Johnson Space Center from where I live. So I would go by the Space Center each time I went sailing, which was not often enough, but with sufficient frequency that I really began to feel at home at NASA.

Of course, we had many friends down in that area, which also gave us another connection with NASA. I think that my acceptance of the private sector's role in space was a little bit easier to come by than if I hadn't had that association.

When I was exposed to the idea that we were closer to utilizing space than most people thought, I think it was very natural that I accepted that concept. We spent a substantial amount of time looking into the possibile means of going into space, because I feel that space is a frontier that can be developed and should be developed.

Our initial insight was that space development would have to be a major operation by the Government or some large corporation. It didn't occur to us that we could really take an alternative course until about 2 years ago, when I met Gary Hudson, who was building a little company in Sunnyvale, Calif., and contended that he could indeed build an inexpensive space vehicle. The more we talked about it, the more we felt that it would be worth a try.

I got together some of my friends from the real estate business and asked them if they would be willing to underwrite such a venture. I think they came along initially more because of our past associations than because of the project. But once they got together with Gary and we were able to lay out our program for building this inexpensive vehicle, the more realistic the project became.

We did get together to begin work on that project about a year ago. I think we did prove that we could build an inexpensive vehicle. I don't know that we have proved we could build an inexpensive vehicle that would work, because vehicle tests ended in a rather spectacular failure, but I feel that one of the things that this country has got to come back to is the feeling that we can fail. I think our society has put so much stress on success that we have been limited in our ability to go out and try new things, because we are afraid that if we fail we will be penalized unduly. But I think our group felt we could go out and give it a try.

One interesting thing about our investors is that there is only one investor under 50 years of age. So I think it isn't a matter of the age of people; I think it is a matter of how they look at what can be done. We built that vehicle in less than a year's time, and we had it on the stand down there on Matagorda Island. The day we put it up on the stand was really a very exciting time—to see that rocket actually sitting on the stand with all the wiring and all the instruments tied into it.

The rocket construction was very well done. On our first attempted engine test, we had an abortive failure, because the wick that was supposed to ignite the motor didn't perform its function. But we did have an opportunity to try the whole ignition sequence, so we knew we had the rocket systems wired in right. We even tested the fail safe process of bleeding off, or venting, the liquid oxygen and thus eliminating the danger of the kerosene to those around us. So we were able to test the vehicle to the extent that we knew we had a safe vehicle. We could control it to that degree.

When we tried our engine tests again, we had a series of small failures and a valve misfunction which blew the rocket up on the pad before we had an opportunity to launch the vehicle. I think we did prove that we could build an inexpensive vehicle. I think we have yet to prove that we can build an inexpensive vehicle that works, but events since the explosion have been very gratifying.

One of the first things that happened was that NASA came and put their arms around us and said, "Let us tell you what went wrong." And I said we would be glad to have NASA come down, and visit with us, and tell us what went wrong. They did. In less than a day's time, they were able to analyze what we had done, the cause of the explosion, and how we could correct the flaw. That was just the beginning, I think, of a really closer relationship with NASA. They have been wonderful about offering us help and giving us advice.

We also made contacts down in Texas with NASA people who have retired. A lot of the people in NASA have taken early retirement. In fact, I think there have been over 300 retirements in the last year and a half down there. Most of these people are in the age group 55 to 60, and they have had tremendous experience in the industry. So it isn't a matter of them not knowing what goes on; they do.

In fact, one of our interesting stories developed when we took one of the suggested rocket plans down for review by one of these men, who looked at it a few minutes and said, "I am very familiar with that because I helped design it." So these former NASA personnel are well-informed, and that vast amount of knowledge is available to people who want to come in and utilize it, because most of these retirees are playing golf in the morning and then coming into the office a little while in the afternoon.

Mr. FLIPPO. Mr. Hannah, may I interrupt you to ask a question? I believe you said there were several retirees there, highly qualified, capable, talented people.

Mr. HANNAH. Yes sir.

Mr. FLIPPO. Why do you suppose they retired?

Mr. HANNAH. They said that they were just frustrated with the lack of forward movement. They didn't feel that they were really performing up to their capabilities and wanted a place where they could. When they weren't allowed to do so within NASA, I think they just felt that they would be more productive in retirement. I think they were hoping to go into retirement and then get an opportunity to on occasion offer their services on a contractual basis.

That is what they are doing for us, working on an hourly or daily basis. By using retired NASA people, we are able to keep our overhead very low, because we only use them when we have to have them for a particular job. This procedure gives us an opportunity to avail ourselves of their expertise at a very nominal cost. I think that these people are available to anybody who wants to take this route. I don't think we are unique. I don't think we are getting any service that anybody else that went down there wouldn't get.

Mr. FLIPPO. We have the capability to go forward but we are not utilizing it?

Mr. HANNAH. That is right, yes sir. And I am not so sure that it isn't just as wise that the private sector does take over. I think it is high time that the private sector stepped up and said "Here, let us have a try at it." I am confident that if we are given the Government's ground rules for private space development, we can begin to produce, and produce very readily.

There is no question in my mind that the market is there. We have made enough of a study to know the market exists. It may not be a large market to start off with, but the lower the cost of the launches, the larger the available market.

I think a good example of this theory is the development of the computer industry over the last 10 years. No one would have predicted the breadth of current usages for computers. I think we will find the same phenomenon in space. The cheaper the price of the launch vehicle, the more usages there will be.

If we assume that the technology is there, if we assume the personnel are there, if we assume that the vehicles are available—or can be made available—and that we can put our own hardware on them and adapt them to a particular use—then the only thing that remains is providing the service cheaply enough that a customer will come up and buy what we have to sell. That is a product, I think, of salesmanship as much as anything else.

I don't think you have to sell a set figure and say we have to provide space transportation *x* number of dollars. I think what we have to do is set the pattern and let the entrepreneurs come in and sell Tom Jones on using this service. If we can make enough of a pitch, other companies can get excited about space development. That is what we are doing. We are finding that there is that kind of responsibility.

One of the interesting things that really amazed me was day after the explosion, when we had three potential customers call us to be sure we were going to continue and not give up. So I think that the demand is there. I think it is just a matter of making the ground rules that we have to work with clear enough that the private sector can get in there and get their teeth into space development.

One of the difficulties that we are having—and one of the areas in which I think your committee can help us the most—is getting specification and clarification of those guidelines and rules under which we must work. We need to have some guidelines on who is going to be the lead agency to regulate us—for example who do we go to see for requirements and approval for a launchsite at a particular spot?

If we are given those guidelines and those rules to work with, I don't think there is any question that there will be many more space services coming up and taking the step forward as we have. I think it is going to be sort of like the 4-minute mile. Once we break through the barrier, I think there will be a lot of others doing it on a consistent basis thereafter.

I don't see any practical obstacles to overcome. I think technologically we have the ability; the hardware is there. The personnel to operate the hardware are available. It is just a matter of putting the elements together under guidelines established by Congress and the Federal Government.

So I think that is mainly where we are and what we would like to have your committee consider. I'd like to discuss our five main concerns, which we wanted to outline.

First, is who—which lead agency—regulates launches, which I have already mentioned.

Second, how does a private firm go about getting a launchsite approved? If you wanted to set up a private launchsite, how would you go about ascertaining what rules you would have to go by and how those rules would be established?

Third, we would certainly want to know the liability rules. Right now, under international treaty the U.S. Government is liable for any damage done by a launch vehicle that would go into orbit and come back. That isn't consistent with the liability of airlines which fly over foreign territory. Such airlines are ressonsible and have to get insurance to cover possible damages.

I think it would be reasonable for private sector firms to obtain their own insurance, so the Government would not be liable. I think the international regulations certainly should be looked into very thoroughly by your committee, so the private sector and the

Nation aren't penalized by not being aggressive in that particular area.

Fourth, I don't think other countries are as reluctant to utilize space as we are. If the private sector is given the mandate to go forward, and we do not volate any of the international regulations—discussed next—we ought to be encouraged to do so. The Government ought to say that the Nation's policy is to encourage private development of space.

Finally, I think we need to have an international position from the Government that the private sector is going to be recognized in space. Right now we are the only major country in the world that really advocates the free use of space by the private sector. I think if we don't assert ourselves and make that position the policy of our Government, by default the development of space will be done by governmental entities. I think we, as a free enterprise nation, certainly should take the lead role in recognizing the legitimacy of private activities.

So those are the areas where I feel that we can help each other. I couldn't say enough nice things about NASA, because they have really been helpful to us, and they have done a grand job officially and unofficially. I think that will continue, as far as we can tell.

Mr. **Flippo**. Do you plan to have a commercial launchsite? Is that in your current plans?

Mr. **Hannah**. We would like to.

Mr. **Flippo**. But you have not located the specific place?

Mr. **Hannah**. No, sir.

Mr. **Flippo**. Do you plan to use an existing DOD or NASA facility, through contract?

Mr. **Hannah**. We would like to have clear guidelines before we go that far forward. That is one of the areas I think we could certainly use some guidance in, because we don't feel that we would want to go to a NASA control site if we didn't know what guidelines and rules we would have to adhere to.

Mr. **Flippo**. Would you comment on legal implications of launching from a private site?

Mr. **Hannah**. I think that we would very much need an environmental impact study of the area that we choose. There just are not an awful lot of sites that you can use for a launchsite, so possible sites would be limited. Once you determined where those sites were and made an environmental impact study as you do for any other commercial operation, then I think we could go foward if we were covered by insurance—liability insurance. I think we could act very responsibly from a private launchsite.

Mr. **Flippo**. When in 1982 do you plan your next test?

Mr. **Hannah**. We hope by the end of 1982. We are moving forward as fast as we can.

One of the other interesting things that has come about is that since our endeavor and our failure at Matagorda, we have got a lot more interest from the people that have abilities in this field. So our bids are coming in a much more realistic way, and we may be able to offer launch services quicker because of the additional input we have got from the people who are able to perform such activities.

Mr. **Flippo**. Do you have any comments on shifting of the Shuttle (once it becomes operational), to the private sector, and how that might be accomplished?

Mr. **Hannah**. No, sir, I really don't. We really haven't thought in those terms, Congressman. Our interest has been more in small payloads. We are not looking at ourselves as being in competition with the Shuttle, but more as supplementing the Shuttle and servicing the small payloads that they wouldn't particularly be interested in.

Mr. **Flippo**. Obviously, you want the private sector to be more involved in civilian programs. How about military programs? You are in the economic realm.

Mr. **Hannah**. We want to stay in the private sector and want to stay in the commercial space sector? I would hope we could stay pretty free of the military.

Mr. **Flippo**. Could you comment on the planned sizes and payload capabilities of Space Services, rockets?

Mr. **Hannah**. We initially planned to place a 300- to 500-pound load in low Earth orbit, then to go into the geo-orbit with maybe up to a 1,000 pounds. We hope to keep the payload down to that size, not try to do large loads at this particular time, try to learn as we go along, and continue to increase the size as we learn more about what we are doing.

Mr. **Flippo**. Would you compare the cost, do you have any cost comparison that you could make about cost of launching on your rockets as opposed to NASA or militarily?

Mr. **Hannah**. The only figure that I think would be a safe figure to go with would be one that I was told at NASA, which is what they figure in when they man their operation, which is about 30 percent of their operation. So we feel that since we aren't going on a manned space venture, we could cut our cost by that 30 percent. I also feel we might be a little more efficient by virtue of our size. So I would say 30 to 40 percent below the existing cost.

Mr. **Flippo**. Are you familiar with the sounding rocket launch site for the Rocket Research Institute in California?

Mr. **Hannah**. Yes.

Mr. **Flippo**. That is under the authority of the FAA.

Mr. **Hannah**. As I understand it; yes sir.

Mr. **Flippo**. Mr. Hall.

Mr. **Hall**. Mr. Hannah, I am familiar with you somewhat and your background through Dr. John Moseley.

Mr. **Hannah**. Yes, sir.

Mr. **Hall**. I am not pleased with your failure, but I think it certainly brought attention to you. It might be some solace to you to know there is a monument to a former President who failed several times before he got his first political office, so historians tell us.

Mr. **Hannah**. Yes, sir.

Mr. **Hall**. You know in smaller airports they keep looking for a place to put the glider pilots. Do you kind of have that feeling about being allocated space or being sent to some part of the terrain for your launches?

Mr. **Hannah**. I hadn't thought of that.

Mr. **Hall**. You are suggesting that that happens?

Mr. HANNAH. I hadn't thought about it quite like that, but I think we would be very glad to be in the periphery so long as we could perform. I think our major goal is to try to get something up in space as quickly as possible.

Mr. HALL. Under international treaty, as you have pointed out—and I appreciate very much your presentation here—you pointed that the U.S. Government is liable for the consequences of a private launch.

Mr. HANNAH. Yes, sir.

Mr. HALL. First, what did you have to do to get the authority to enter into the attempt to make such a launch?

Mr. HANNAH. We had to get the FAA's approval and we had to get the FCC's approval for our previous planned launch. We did have insurance.

Mr. HALL. That was my next question. What insurance did you have?

Mr. HANNAH. Such insurance is available, and it is available to the private sector. We were able to get it with one company. We have had two or three other companies calling wanting to write our insurance, so I don't think insurance will be any trouble at all, any amount that would be needed, so long as it was specified and we knew our liability limits.

I don't think it would be quite fair to leave that open and to have us pay a higher premium than some other company that would be operating in the same field.

Mr. HALL. Space Services certainly received a lot of national and international attention. Do you attribute that to people's interest to see the private sector move in and eventually take over?

Mr. HANNAH. I really do. We were really quite amazed at the response we got. We didn't realize it would be quite that strong. But we have had tremendous response; a day doesn't go by that someone doesn't either call and want to come to work for us or want to help us or give us encouragement to go forward. So there is a very broad base of interest. It isn't just local, it is all over the country, all over the world, as a matter of fact.

I think our explosion made the front pages of newspapers all over—I have got reports from India and Australia and England and Germany. So you don't like to have that kind of publicity, but at least it shows the interest that we generated.

Mr. HALL. You were the very first in the private sector, right?

Mr. HANNAH. Well, I think so. I think it depends on how you define private sector and what we are doing, because there are other private operations in space, but I think we are the first ones that took a rocket from the word go and did what we did with it; yes, sir.

Mr. HALL. Of course, there are going to be some governmental policies or legislation that you and those with whom you are associated envision that we are going to need to enable the private sector to provide space services, exploratory services. Did you address that? I didn't get a chance to read your entire presentation.

Mr. HANNAH. Yes, sir, we certainly did. We outlined it pretty clearly. I think if you would like additional information, we would be glad to get it to the committee.

Mr. HALL. As a little-bitty guy compared to the U.S. Government, do you consider yourself as being in competition with NASA?

Mr. HANNAH. No, I really don't. I think that there is a real way that we can work together. There is a role NASA plays. I think they have already played a tremendous role in setting the stage. If we can come along and take advantage of that, I think there is a good marriage. I think that, to me, is Government at its best, when it takes the initiative and shows us the way, and then the private sector comes along and benefits from the leadership role the Government has taken. I think that the response we have got from NASA, the help that we have got, and just the helpful big brother attitude has just been great. It is a real healthy situation there.

Mr. HALL. It is obvious that not just the eyes of Texas were upon you, the eyes of the world were. I think they gloried in your spunk and will really be pulling for you on your next attempt.

Mr. HANNAH. Well, thank you, sir.

Mr. HALL. I am not too much at developing or detecting or inventing anything. My youngest son cut a garden hose and put it around his waist and rolled it and I whipped him for ruining the garden hose, and about a year later, someone came out with the hoola hoop. I think certainly we wait for people like you to come forward. I appreciate your presentation.

Mr. FLIPPO. Thank you, Mr. Hall.

Mr. Lowery.

Mr. Brown. The gentleman from California, who has a great interest in space policy.

Mr. BROWN. We have a great interest in space, even when it appears that Texas is getting the lead on California.

I am very much interested in the kind of analysis that you made before undertaking this enterprise. I am sure you looked very carefully at the market potential in this area?

Mr. HANNAH. Yes sir.

Mr. BROWN. There seem to be two large areas, the space communications area, and the near Earth surveillance activities that pose market potentialities.

I just wondered—and I didn't detect enough detail in your statement—as to where you saw the primary market opportunities in near Earth space activities. Or is that a commercial secret?

Mr. HANNAH. No sir. I think that the low Earth sensing market is the one I see expanding the most rapidly. The way the oil companies are using it to pick up major fault blocks is one of the applications. But I think that there are so many things that could be tried, that if we provide an opportunity to explore, such efforts might just pay off very handsomely.

So we see an expanding market in low Earth sensing, even using the low Earth orbit for doing certain types of communications. There are those applications that would develop a cheaper type of communication than you get on geocentric orbit. So those two areas are the ones I think are the most exciting.

We hope to get into the geo-orbit eventually, but we will try to build a base with the low Earth orbit, because it is so much easier to get into that level. I have no question in my mind that if we offer the services, that there will be an entrepreneur spirit, that people will come forward with applications for that Earth sensing.

Mr. **Brown**. Did your own analysis extend beyond the launch services to the provision of sensing equipment or other aspects of the commercial opportunities in this area?

Mr. **Hannah**. One of the things we tried to concentrate on was to limit what we were attempting to do and not try to do more than we could. By virtue of zeroing in on just transportation, we felt we could do a quicker and more effective job and a cheaper job. There seems to be no lack of people who have equipment and payloads to try in the upper stages. There doesn't seem to be a shortage.

Mr. **Brown**. You are pretty safe in that statement, are you?

Mr. **Hannah**. We feel safe in that statement, yes.

Mr. **Brown**. So your strategy is to take the matter one step at a time by providing an economical launch service, and then develop the payload applications based upon the low cost launch availability?

Mr. **Hannah**. That is the idea, yes sir.

Mr. **Brown**. Thank you very much.

Mr. **Flippo**. Thank you, Mr. Brown.

On the last page of your testimony, Mr. Hannah, you make the statement that "our course is clear, and the need is urgent, and we must act now." Now, specifically, what legislation is needed now to move forward? What should Congress do to facilitate a healthy future space program?

Mr. **Hannah**. Right now, immediately, we can continue to go forward like we have. I think we did enough of our groundwork in this last attempt that we can work through the system. I think the need, as I see it, is to have a lead agency so we don't have to wander through the agencies and wonder whether they have authority. We need a clearcut authority. What would be most helpful to us right now would be to give us that line of authority.

The second level of help, I think, would be a statement from the Congress that the private sector does have a right to go into space, that we as a nation encourage it, and we are going to do everything we can to see they are able to get a foothold in space.

[The prepared statement of Mr. Hannah follows:]

TESTIMONY

by

David Hannah, Jr., President

Space Services, Inc.

Before the

Committee on Science and Technology

U.S. House of Representatives

Hearings on Future Space Programs

September 22, 1981

Mr. Chairman and members of the Committee on Science and Technology, I am pleased to be here today to share my views on the potential of the American private sector to contribute to our nation's future in space.

My name is David Hannah, Jr., and I am president of Space Services, Inc., a new company based in Houston, Texas. SSI was incorporated in September of 1980 to develop and provide economical access to the resources of outer space. We firmly believe that space represents a virtually unlimited frontier for economic development that will produce diverse benefits for our country and all humanity.

In the near term, we believe that the key to developing space resources is the provision of truly low-cost, routine transportation to low-earth and geosynchronous orbits. Toward that end we have been engaged in a project to design and operate this country's first private, commercial space launch service. As you may be aware, one of the initial tests resulted in an explosion that destroyed our test vehicle. Of course, from the beginning of the project we had to anticipate such a possibility; in the rocket business failures are frequently explosive. We are now at work on a second vehicle, and we expect to conduct our next test flight in 1982.

Mr. Chairman, I believe that we are living in tremendously exciting and historically significant times. In just over twenty years, we have shifted our perspective from the narrow opportuntities and resources of a single planet to the broad potential of space. During this past year, the maiden flight of Columbia and the recent Voyager missions have simultaneously initiated a new age of spaceflight and opened our eyes and minds to the edge of the solar system. The future prospects for space exploration and development are, perhaps, even greater--as demonstrated by the witnesses and ideas at these hearings.

Throughout the past two decades in space, government and industry have evolved a productive partnership. Together, NASA and industry have developed space technologies unrivaled by those of any nation. Paradoxically, this partnership has proved so successful that it has created far more opportunities for space exploration and development than governmental programs can possibly exploit. This is especially true at a time when the government holds itself stringently accountable for the allocation of national resources.

This situation--virtually unlimited future opportunities in space constrained by tight limits on available national resources for these activities--has prompted many observers to doubt our nation's ability to meet all the challenges that lie before us in space. It is now a truism: for every new space venture the government undertakes, one or more projects of equal worth cannot be initiated.

However, I contend that we can act today to mitigate the impact of scarce governmental resources, which even now are causing reductions in the national commitment to space exploration and development. Specifically, we can infuse new resources and talented individuals from the private sector into the national space effort, significantly extending our country's capability to explore, develop, and benefit from space.

Historically, the United States has opened and developed new economic, scientific, and physical frontiers by fostering partnerships between government and industry. Government has played a leading role, both by assuming early risks and by providing the initial technical and economic infrastructure required for subsequent development by industry.

In my opinion, now is the time for the private sector to take advantage of the tremendous accomplishments of NASA by efficiently and responsibly developing the resources of space for the benefit of society. Government has fulfilled its responsibility to open the new frontier, and it is now incumbent upon Space Services and all the companies which will follow to make the frontier accessible for industrialization and commercialization.

Such activity logically is a function of private enterprise for a number of reasons. First, a significant international market already exists for expendable launch vehicles capable of placing satellites in orbit. A recent study by the American Institute of Aeronautics and Astronautics concluded that commercial demand for space launch services during the 1980s--even with an expanded Shuttle fleet--"necessitates reestablishing a strong stable of expendable launch vehicles as soon as possible. Without these moves the U.S. will suffer in international space business competition." Indeed, we already may be witnessing the effects of a shortage of domestically produced launch vehicles. The European Ariane rocket recently signed its first American customer for a satellite launch. Moreover, a recent edition of Japan Times reported that Japan's Ministry of International Trade and Industry "has begun taking steps to transform Japan's space program from a loosely organized network of research projects into an industry...Space will be a $4.5 billion industry for Japanese manufacturers by the mid 1990s, comparable in size to today's radio and television manufacturing industry." Thus, the United States must overcome significant competitive challenges if we are to maintain technological and economic leadership in space during the next decade, with the attendant impacts on jobs, the balance of payments, and the overall economic well-being of the nation. Clearly, governmental programs alone cannot meet these international challenges: the U.S. private sector must share leadership in space development.

Second, vigorous activity by private enterprise to industrialize and commercialize space could free governmental resources for other important space projects, such as advanced technological research and development and space science research, two pioneering areas which probably are best managed by NASA.

Finally, it is important that the American system of free enterprise establish a foothold on the new space frontier. Practically, one good way of lowering costs and increasing the overall efficiency of space operations is to let competitive market forces determine the direction and pace of space development. Philosophically, can we as a nation of free individuals afford to permit the nation's largest and potentially most productive frontier to be developed solely by government programs? To do so would be to turn our backs on our history and on the institution of capitalism which has served us so well throughout our past.

I believe that Space Services, Inc., is just one of what ultimately will be a host of new companies formed to develop the space frontier. Over time this new industry will make significant contributions to the well-being of all people on earth.

In any new industry, success depends on a variety of factors. In the case of private space activities, these factors include technology, capital, and governmental policy. The first two, although challenging, do not currently constitute significant barriers to the establishment and growth of a vigorous private sector space industry. However, the situation with respect to governmental regulatory policy is less clear.

Obviously the governmental regulatory structure applicable to private space ventures will play a critical role in the success or failure of such initiatives. The government has certain legitimate concerns about private space launches, as well as a responsibility to establish regulations in the national interest. However, it is equally important to construct regulatory policies which do not unnecessarily inhibit private space enterprise. An optimal regulatory scheme will be established only by balancing these competing requirements.

I believe that the government should act to ensure that any private sector launch program protects the public safety and does not endanger our national security. At the same time, the government should eliminate the present patchwork approach of multiple agencies with uncertain authority issuing uncoordinated regulations to control private space ventures.

Ideally, the government should formulate an overall policy which favors and encourages the participation of the free enterprise system in space operations. Such a policy would recognize that business is as responsible as government to the best interests of the public in a free society. Increasingly, the demands of the marketplace dictate that irresponsible activities by individual corporations simply are not profitable, and therefore not in the company's or society's best interests. If the government bases its regulations on this premise, the result surely will be a system of general, industry-wide operating regulations which best serve the public interest.

As I mentioned earlier, the initial key to near-term space industrialization is the provision of low-cost launch services. Consequently, it seems reasonable that policymakers should direct their immediate attention to constructing a regulatory framework for private launches. Although certain agencies (for example, the Federal Aviation Administration and the Federal Communications Commission) exercise limited authority over private rocket launches, the government has not designated a single lead agency with the mandate to integrate all governmental concerns into a set of operating regulations for private launch enterprises. The need for such a lead agency is increasingly pressing. FAA's experience in administering similar regulations for private commercial airlines, as well as the agency's existing (but limited) aerospace authority, may qualify the FAA for lead agency status, with an expanded mandate encompassing aviation and aerospace activities. Such a policy would seem to fulfill many obligations, including those under the 1967 United Nations outer space treaty, which requires the United States to authorize and supervise private launches from American territory. Perhaps the government's interests would be best satisfied by a system that approves companies interested in private launches by conducting a qualifying flight under governmental supervision.

As the private space industry matures, existing federal launch centers will not be able to provide sufficient facilities to meet the demand for spaceflight operations. Consequently, the private sector will seek to develop new launch sites. Thus, regulatory authority over private launches also should address the proper governmental role in the construction and operation of new commercial launch sites. The government may wish to establish a federal range officer program, locating a federally-appointed officer on site to ensure compliance with governmental regulations--for example, to verify that only licensed payloads are launched.

A final prerequisite for private sector participation in space launch operations is a system to indemnify the government against possible accidents resulting from private launches. Under present international treaty, the U.S. government is liable for the consequences of any private launch. The government should require each private launch company to carry an adequate amount of liability insurance.

If such a regulatory policy is implemented, I have no doubt that an entirely new sector of American private industry soon will be making significant contributions to the national economy. In the longer term, policymakers ought to give careful consideration to the types of national policies that might best promote private sector space development. As I noted earlier, space rapidly is becoming an arena of international economic competition that we cannot afford to neglect.

Although there are numerous long-term issues which are important to the future of private industry in space, I would like to discuss two which seem to me to be particularly consequential. First, we should examine most carefully any international treaties or agreements relevant to the use of outer space. In comparison to other nations, the U.S. appears to underestimate the economic and political significance of the space frontier. Yet, the U.S. must exercise leadership in the development of international space policies; no other nation has as great an interest in preserving the free market approach to space development as the United States. It is therefore vital that our diplomats and policymakers always aggressively defend and preserve the right of American citizens to peacefully and lawfully engage in developing the next frontier. If this conviction is absent from our international posture, no amount of domestic policy or legislation will overcome the international barriers to space operations by private enterprise.

A second long-term, overarching policy issue addresses the appropriate relation between the governmentally-subsidized space program and private sector space activities. The national interest obviously demands the maintenance of a vigorous federal space transportation sector, but that justification does not necessarily extend to federal subsidies for space ventures which compete with or preempt legitimate private sector firms seeking to launch commercial payloads. The private sector does not need federal subsidies to successfully compete for commercial payloads. At the same time, federally-subsidized transportation, at some level, could substantially undercut this fledgling industry before the new firms can establish themselves. From the outset of our operations, we have maintained that a significant market demands our launch services. But this claim is valid only to the extent that federal policies (for example, the pricing of Shuttle payloads) reflect the approximate true cost of operating the vehicle. In short, we cannot afford an artificial "price war" with federally-subsidized space transportation and services. I do not believe that such a conflict is likely in the near term, yet I think that in the past this very prospect may have discouraged others from entering this industry. We strongly believe that a carefully-crafted government policy can ensure that NASA and private sector activities are complementary rather than competitive. Of course, some space activities undoubtedly will remain largely under NASA's jurisdiction; for example, the private sector may not match NASA's expertise and interest in space research and exploration. However, the increasing activities of foreign space enterprises--usually well-subsidized by foreign governments--argues for a coordinated federal space policy that recognizes and maximizes the strengths of both NASA and the private sector.

Mr. Chairman and members of the Committee, if the private sector and the government work together for the peaceful development of the vast resources of space, I believe that a better world for our children and grandchildren will be the inevitable result. We confront an unparalleled opportunity whose significance is well understood by both other nations and the international economic community. To safeguard our stake in the space frontier and our status as a technological leader, we must defend our national interests in international forums and develop clear and positive domestic space policies. Our course is clear--the need is urgent--we must act now.

Mr. FLIPPO. Mr. Hannah, thank you very much for your testimony. It has been very enlightening.

Mr. Hall.

Mr. HALL. Mr. Chairman, when you speak of authority, have you thought about whether or not the authority is in this committee or would it be in the Commerce Committee? Would there be any reason why this would not be the committee, the vehicle for such a pursuit?

Mr. FLIPPO. I think it would be the jurisdiction of this committee and you and I and other members of the committee will be talking about it soon. As a matter of fact, I think Mr. Brown has introduced some legislation about space policy before. This might be included in such an attempt, I would think.

Thank you very much for being with us and giving us the benefit of your experience.

Mr. HANNAH. Thank you.

Mr. BROWN. Mr. Chairman.

Mr. FLIPPO. Yes sir.

Mr. BROWN. Would you indulge me for a brief statement which I should have made earlier?

Mr. FLIPPO. Absolutely. We are pleased to have your statement.

Mr. BROWN. I apologize for not being here yesterday when the hearings opened. I was in California and very much wanted to be here, and I have a very brief opening statement which I would like to have inserted, if I may.

Mr. Chairman, I would like to congratulate you for initiating these hearings. I am very much impressed by the preparation and background that has gone into the consideration of this extremely important area.

As you commented, I introduced earlier a National Space Policy Act of 1981 which takes as its foundation the recommendations of the report issued earlier by the subcommittee itself regarding civilian space policy. The bill is not a perfect bill, but I hope it can help to serve as a vehicle for pursuit of a sound, forward-looking and responsible space policy which would help us match our previous successes, as well as live up to our high expectations.

Obviously, such a policy should incorporate an adequate, proper role for the free enterprise sector in the Nation's space effort. In the area of space technology of course, years of groundwork, planning and development are necessary to foster a successful program and hence the importance of having a sound policy base for it. These hearings will help to provide that policy base, and I am particularly reassured at the attention you are giving this issue in the absence of an articulated national space policy on the part of this administration.

Thank you, Mr. Chairman.

Mr. FLIPPO. Thank you, Mr. Brown.

Our second witness today is Mr. Stan Kent. Mr. Kent has raised private money, largely from small contributors, to support space missions financially. His latest effort is the Halley Fund for a mission to that comet.

In addition, he is trying to organize grassroots support for a more vigorous space program, and we certainly want to hear of these activities.

Would you please come forward and give us the benefit of your experience, Mr. Kent?

[A biographical sketch of Mr. Kent follows:]

BIOGRAPHY

STAN KENT

Stan Kent has been involved in all aspects of space exploration since he left his native England immediately after high school graduation in 1973, to pursue a career in the space age. Since that time, Stan received a B.S. and M.S. in Astronautics from Stanford University.

While still a student at Stanford, Stan was chosen to represent the American Institute of Aeronautics and Astronautics at the 1978 International Astronautical Federation Congress held in Dubrovnik, Yugoslavia. The prestigious Herman Oberth Gold Medal, awarded for the most outstanding student paper in astronautics, was presented to Stan at the Congress for his remarkable research paper describing a novel concept for space vehicle re-entry and recovery.

Subsequent to his graduation from Stanford, Stan was employed by the Boeing Aerospace Company in Seattle, Washington, where he gained experience in space vehicle design and advanced space programs. Stan was later employed by the Aerojet Liquid Rocket Company in Sacramento, California, where he worked on single-stage-to-orbit rocket engine design. He is currently employed by the Lockheed Missiles and Space Company in Sunnyvale, California, where he is a research engineer investigating unique mission applications for the Solar Electric Propulsion Stage (SEPS). In addition, Stan has served as a special consultant to Dr. Robert Frosch, former Administrator of NASA, on advanced programs and future directions for the national space program.

Stan is currently the President of Delta Vee, Inc., a new non-profit scientific research and educational organization dedicated to the exploration of space. He is also the Director of Delta Vee's Viking and Halley Funds, which involve the general public in directly funding the exploration of space. In this capacity, Stan has traveled the country promoting the space program and he has appeared on over 100 radio and television talk shows.

A prolific author, Stan's articles about popular and technical aspects of the space age have appeared in OMNI Magazine, Future Life Magazine, the AIAA Student Journal, and several technical journals and volumes.

STATEMENT OF STAN KENT, PRESIDENT, DELTA VEE, INC.

Mr. KENT. Before I go into the programs of Delta Vee, I would like to give you a little of my own background because I think it typifies an aspect of the benefits of the space program little recognized today—that is the vision it can give a young person. I grew up in the working class slums of England. The typical outlook for your average school kid in England is to grow up, get out of school at 16 and go to work in the local tire or car factory.

It appeared to me that there has got to be something more to life than that. I had always been interested in science, aviation, science fiction, space flight. Then *Apollo* happened. That convinced me there was a better tomorrow. I can remember sitting in front of a television set watching the first moon flights thinking the future is in space, and America is the country, it is going into space. I belong there. That is a bold decision for a 10-year-old kid to make but my resolve never faltered, largely due to NASA.

I wrote to NASA as a starry eyed kid saying I want to build and fly the space vehicles of tomorrow. NASA actually wrote back. Now, can you imagine the effect that a personal letter has to a 10-year-old kid in England that comes from the U.S. Space Agency? It wasn't just a letter. They sent books talking about what you should study, what type of skills you needed. Before I knew it, I was applying to U.S. universities and I got a scholarship and degree in astronautics and went to work in the space industry.

Now, I had always been very active as a student because I felt there was a need to get more people like myself involved. As I got into the aerospace industry, I kept that activism going, but all through my professional career there was a certain frustration that that drive, that fire, that imagination that enticed me from England, had gone away. The industry had lost a little bit, it wasn't as dynamic, it wasn't as foresighted as it was before.

There seemed to be a certain sense of, oh, the public isn't interested in space. There will be no more big missions. I had too many complaints like that from managers and engineers. That really frustrated me. I mean, if Apollo could so move me to leave my home, then it could have done that for other people. In a sense, the seeds that John Kennedy sowed are being reaped now. The Apollo generation is coming home and I think I represent that generation. I think there are a lot of people that the Apollo program did not turn off. It excited them to go on and do more.

I resolved that it wasn't enough just to be an aerospace engineer. I had to communicate some of the excitement, some of the vision that I felt. To do that, I began a crusade of selling the space program, not only to students, to the general public, but to NASA and the aerospace industry itself, because I want to relight that fire that was so evident in Von Braun's days.

I am still an engineer designing the vehicles of tomorrow, but the program that began a couple of years ago is now growing at such a rate that someday I hope to be designing space vehicles for it.

I am president of a citizen's supported nonprofit space corporation. Its name is Delta Vee. Delta Vee is a technical term meaning change in velocity. You oftentimes hear aerospace engineers talking about the need to maximize Delta Vee. Delta Vee is the most important design program meter. Plain and simply, we wish to increase the speed with which we expand human civilization into space.

I feel that a corporation that involves the public in its day-to-day activities is pivotal to an expansion of our current dormant program. Delta Vee is truly a space corporation of the people, for the people, and by the people, and I represent over 15,000 people who have contributed their hard-earned dollars and ideas to help support NASA programs.

As a demonstration, I brought along several thousand letters that we received—about 2 month's worth of mail. I have entered some of their comments into the record and would like to read you some of those. Before doing that, I would like to explain a little bit why people send in their money and ideas. Before doing that, I would like to show you what 2,000 letters looks like.

That is not all of it. Can you imagine what an all-volunteer organization does when something like that comes in in 1 to 2 months, when all this mail—and it is not just money they are sending. I can pick them up and inside there are tremendous ideas of, "Hey, why don't you do this?" "Why don't you do that?" The response is overwhelming. It has convinced us that the public desperately wants to be a part of the space program.

We are best known for organizing space groups and the citizenry in general, to form the Viking Fund. We have raised over $100,000 to keep the Viking lander on Mars operating. The Viking Fund was suggested to me by another English space refugee, Eric Burgess. Eric was involved in the space program long before there was one in the thirties. He helped form the British Interplanetary Society and he was science adviser on the James Bond movie, "Moonraker." That emphasized the entertainment possibilities of space exploration to Eric.

In one of our usual talks about the sad states of the space program, Eric said "you know, if you went to the public and said put your money where your mouth is they would love to. They would send you their money and they would pay for the exploration of space." At the same time, he mentioned that the Viking perhaps needed extra funds and that that would be an excellent program to see if the public would put their money where their mouths are, above and beyond their normal tax dollars.

So a group of engineers, students, enthusiasts, and businessmen, got together and formed the Viking Fund under the auspices of the American Astronautical Society. It was announced in the May 1980 issue of Omni magazine and Omni has been instrumental in publicizing the fund on a regular basis. We were overwhelmed. Literally in 1 month, 4,000 letters came in containing $40,000, an average of $10 per person.

We felt vindicated that there was so much interest that they would actually send in money and ideas. Now we have gone a little bit beyond that. We have received help from all sorts of places, companies, Boy Scouts, science fiction clubs. You name it. And the basis for the success of the Viking Fund, I think, lies in the public's desire for direct participation in the program.

Before the Viking Fund, the public had to sit back and watch it on the TV and think how wonderful or perhaps if they really got motivated, they would write a letter to you or your colleagues. Now, the Viking Fund has added a whole new dimension to space exploration. I don't think we can quite guess at all its implications right now.

In looking back, I think one of the most significant achievements of the Viking Fund was that we actually established a working relationship with NASA. Historically those of the space community that have tried to promote NASA have not met with too much corporation from the agency itself. This is understandable. NASA was initially skeptical. I mean, how many people voluntarily want to give money to the Government? Their reaction was one of a little bit of mistrust. But insistence on our part paid off largely due to the efforts of NASA's Director of Public Affairs, Brian Duff, and the late Associate Administrator for Space Science, Tim Mutch.

What Brian and Tim did was remove the infamous unconditionality restrictions. This says anyone can give money to the Government but the Government can't turn around and guarantee they will spend that money on what the donor gave the money for. That presented a little bit of a problem to all these people who sent in money. What NASA did was really precedent-setting and they should be commended for their foresight. In effect, NASA said OK, what we will do, we will work for the Viking Fund. They established a contractual agreement. In much the same way that Congress funds NASA, the Viking Fund funded NASA.

We had a certain amount of data and to do a certain amount of analysis. This is a really precedent setting move, because it opened the door now for small amounts of private money to be put into NASA in a sort of cost-sharing arrangement. This could have profound implications for NASA, in these desparate fiscal times. On January 7, 1981, the whole agreement was formalized when we had a dedication ceremony at the National Air Space Museum and turned over an initial $60,000.

One of the other aspects of the Viking Fund, which is also of significance of the Viking Fund, is in the diversity of the contributors. They really represent everybody. We have five-year-old children sending in their allowances; we have got 81-year-old ladies on social security; we even have unemployed people sending in part of their welfare checks; we have got every State of the Union represented and contributions from over 50 foreign countries.

Now, the comments in these letters speak for themselves. I would just like to read you a few because I think they are their own best ambassadors:

For example:

> Here is $5 for the future of our world. I wish I could give $5 million.
>
> I have enclosed a check for $10 as a contribution to continued studies of Mars. It is my sincere wish that we, the concerned citizens of this country, can enable the exploration of space to continue through funds such as this. Good luck.
>
> Research in general and space exploration in particular, should be a number one national priority.
>
> We have relied on quick fixes to solve our problems too long. We must place direct and immediate effort into the long term benefits and solutions to the earth's gravity difficulties that can only be found through space exploration.
>
> It appears that in a current state of lowered expectations and four year policy perspectives, private funding of space exploration may have to become a major source of revenue.
>
> I am beyond the age of thinking about traveling in space myself, but the children I come into contact with are not.
>
> In Honor of Ronald Reagan, we must go forward.
>
> Can you hear us, Washington?
>
> If the government refuses to do anything about the future, then it is up to us, the public, to do something about it.

Now, those are ordinary people's sentiments. They are not aerospace engineers, they are not space scientists. They are ordinary people sitting out there that want to be a part of the space program, and we are going to continue the Viking Fund and activities throughout Viking's life on Mars, which is estimated at another 15 years.

But looming at the edge of the solar system is a new and important space funding challenge. That is Halley's Comet. It returns in

1986 and it appears that the U.S. Government is willing to let this opportunity for technological and scientific progress go begging. At the request of about 11,000 of the Viking Fund contributors, we established the Halley Fund, which is to try and guarantee a U.S. presence at the comet. Fund raising is underway and we are in the midst of a national campaign that asks the public, Government, and industry to come explore Halley's Comet and help save our space program, too.

We have received about $40,000 in 2½ months. Again, though, I think the money is part of it, but the real significant thing that comes in is the contributor's comments. For instance:

> I hope you receive many more dollars, plus many big bucks from the shortsighted budget managers in Washington.
>
> I find the Government's reluctance to properly fund a first, and once in our lifetime, opportunity for a close look at Halley's Comet appalling.
>
> We hope fervently that the Halley Fund is a huge success.
>
> May we all one day see pictures from a comet's nucleus which these dollars have helped us achieve. More important, let's make the politicians hear us.
>
> I am a poor student. Here is one grassroots supporter for NASA and space exploration, so keep up the good work and go get them.
>
> Here's hoping we can save the Halley intercept mission.

Now, I think even whatever budget cuts occur over the next few weeks, we have to have a Halley mission. It is a mission that the public is saying we want to go to the comet. We are fully prepared if Federal funds aren't forthcoming to actually go to private industry and say look, as a sign that America can still do it, will you pay for us to go to the comet? I personally will not give up on getting a mission to Halley's Comet until it is actually on its way and past the Sun.

Those two funds are just one of several programs that we have that make us unique among space interest groups and space corporations in general. We have an advanced projects group financed purely by citizens contributions called the Ferdinand and Isabella Project Support Fund. In this fund we ask the average citizen to place themselves in the role of a space age Ferdinand and Isabella pawning their crown jewels. What would they have us do? What activities would they suggest for Delta Vee?

The most useful suggestion we reward with a bonus trip to see a shuttle launch.

We have had asteroid recovery studies and a host of other ideas. But I would like to describe to you the first Ferdinand and Isabella idea we got from Ketchikan, Alaska. His name was Jim Tennant, and he responded with an idea that was really simple, but very, very well thought out.

It was head and shoulders above the rest. He said:

> If you want to turn the public onto space, you have to get them on the street corners. When they are going to the store, they have to be able to turn in a parking lot and get those pictures of the space program. They have to be able to get it when they want it. They can't write letters; they have to walk in a door, get the pictures and information.

He suggested a space "7-11" store, a neighborhood space center.

We began investigating that, and I am happy to say on September 20, just a couple days ago, we opened the first one in the town of Los Gatos, Calif., the first neighborhood space center, and we were overwhelmed with people coming in to buy the pictures and get all the free information. I hope to see these things franchised around the Nation, a sort of "McDonalds" of space, where people can go in and get the space program on the streets.

It seems what we are doing is bringing space to the consumer, and if this will help fund it, so be it.

Besides, the research and promotion we are into, we are actively in the educational aspect of space exploration. Not a month goes by but one of our staff doesn't give a lecture to a high school or civics group about the subject of careers in space.

It was Delta Vee's staff which helped do the First Careers in Space Conference in July of 1980—and we are already planning to follow up in 1982—we can provide these educational services to the public completely free of charge because we are able to turn around and sell those pictures to pay for this activity.

You will be surprised at the companies who come forward and say, "We can sell this because the space program is so popular. We will give it to you at a real reduced rate." This is one aspect of the private sector we have ignored, and that is the entertainment consumer industry.

We also have plans for several new funds and in particular we would like to have a search for extraterrestrial intelligence. Amongst the stars there lies the answers to many of the problems, many of the questions that humanity has always asked.

NASA has a program that eavesdrops the comunications chatter that might be going around the cosmos, and it is called the search for extraterrestrial intelligence, and the earthly intelligence here in Washington, D.C., has seen fit not to fund the program past 1981.

Many of our contributors have voiced a need for a strong SETI program, so we have a program that is called delta vee's extraterrestrial connection to help fund NASA's SETI program. We will use the Viking fund precedent to pay for searches and perhaps upgrade equipment. Roughly $50,000 will buy a search from one of the radio telescopes in Goldstone or Arecibo. About a million dollars will pay for improved equipment.

One of the other followon activities to come out of the Viking fund is the return to Mars. Surprisingly enough, many of the people who sent in these contributions said, "I don't mind sending you $5 for a Viking, but if you could have a fund to send people to Mars, or robots back to Mars, I would spend hundreds of dollars a month for the rest of my life."

That is a very, very significant statement, because return to Mars hasn't been too popular for a while. I think we got sort of burned on the subject in the late sixties and early seventies, when the moon program died, but people wanted to see that, so we held a conference; we cosponsored a conference at the University of Colorado in May of this year, aimed at studying going back to Mars. The response to that conference was a report by 75 scientists and engineers and the conclusions were rather remarkable. We said we could go back to Mars for a budgetary level of $3 billion a year and with no major technological advances.

In summary, Delta Vee, through its variety of funds, is trying to bring space down to the consumer level. We are convinced the public is willing to put its money where its mouth is, and willing to actually pay for space. There are millions and millions of frustrated space supporters out there, and we have just got to give them a diversity of programs, a way to get involved, and I think you are going to see many of our funding problems disappear.

We have taken this step. With all volunteer labor; we have taken a step without any seed money, and we are now ready for the next giant leap, and I think in considering future space programs, we have to say, "What is the next giant leap?"

For Delta Vee, it involves broadening activity. We are going to actively set up a profitmaking corporation that would be tentatively called Astro Space to go out and try to build some of the products that I think the public wants to see.

For instance, one of the things I have come to understand, as being an advanced designer, is that we really built space travel in a very unbusinesslike fashion.

Space craft designers play a game. What is the mission and in what vehicle? We oftentimes see a mission justified on the basis of a vehicle or a vehicle justified on the basis of a mission, and we play this continual go-around game. Vehicles without missions and missions without vehicles are prime targets for budget cutters. It is a perpetual catch 22.

An excellent example of this quandary is the solar electric propulsion stage. It is a vehicle which will open up the solar system for exploration and exploitation. Yet each year, even though Congress has funded SEPS, SEPS has been cancelled either through presidential or NASA action. This is because every time, even though it can do a variety of missions, there is no planned priority mission for such a vehicle, and so the program gets cut back.

This is a little bit like Henry Ford asking somebody to develop the model T based upon what its mission was. What you really have to do is just go out there and develop it in much the same way that Boeing or Lockheed or McDonnell Douglas builds an airplane. They invest the money, build the plane, and then there is a variety of uses for it that will pay for it.

If you just add up the uses of a vehicle SEPS between now and the year 2000, it is roughly $2 billion worth of missions the government is willing to pay for. That is a pretty good investment for a private group to make, $200 million to develop a vehicle and get $2 billion in revenue over 20 years.

We will invest that. We approach investors and say, "Look, would you be willing to pay the Government and pay Boeing and Lockheed to build a SEPS and operate it like a space line?" And if we are successful, that would mean one of the biggest stumbling blocks to the development of commercial use of space is being removed.

We are confident of the salability of SEPS because, believe it or not, even though it is a fairly obscure program, many of these letters mention the need for advanced space propulsion techniques such as SEPS.

Another giant leap for Delta Vee is going to be the popularization of the Space Shuttle. I think it is essential we keep the Space Shuttle before the public. One way to do that will be to produce a Jacques Cousteau type of documentary in space. Fly members of the news media as observers and produce a documentary of that type that shows the public what science and engineering is doing, in an entertaining fashion. Then eventually, perhaps, ordinary people could be flown as observers.

Perhaps we may need to build another shuttle purely as a space transportation system for people. Perhaps it could be financed through advertising subsidy in much the same way that high performance planes, jets and boats are financed right now. This is a little bit of heresy in the normal way of doing business in the space program, but I think we have really got to look at alternate ways to finance the space program if we are to see it expand to its full potential.

What we are trying to do with Delta Vee and Astro Space is form a pipeline, a partnership with the public, industry, and the Government. Never before in the history of America has there been a corporation that has placed equal priority on the three aspects of research, promotion and education. We are going to try and do that because we are convinced the public has given us a mandate to pioneer the space age. They have put their money where their mouths are and, as representatives of the people, I ask you to do the same.

Listen to them. By working together we can establish incentives for private investment in space activities as well as cost-sharing programs. Delta Vee has grown from absolutely zero in 1½ years through volunteer labor, through many sleepless nights, and we have grown from a club to an organization and now to a corporation, and that is a transition that very few people actually make. I am convinced we can go to even greater heights, but we have got to work together, and we have got to listen to these people.

Thank you.

[The prepared statement of Mr. Kent follows:]

DELTA VEE, inc.
A Citizens Non-Profit Space Corporation
"TOMORROW STARTS HERE"

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9-15-81

STAN KENT: TESTIMONY BEFORE THE HOUSE SUBCOMMITTEE ON SCIENCE AND TECHNOLOGY

I would like to give a little of my own background before describing Delta Vee and its programs, because I think my own experience typifies a little-appreciated benefit of the space program. I grew up amidst the industrial slums of England, where the average outlook for a young adult was to leave school at 16 and go to work in the local tire or car factory. I had always been interested in science, aviation, and space; I was convinced that there had to be more to life than making tires. My suspicions of a better way of life were confirmed by Project Apollo. I can remember watching the first Apollo flights on an old television, and thinking to myself, "The future lies in space, and America is the country who is going into space - that is where I belong". That was quite a bold decision for a 10 year old to make; but thanks to the guidance of NASA, my resolve never faultered. I wrote to NASA describing my desires to come to America and build and fly the spaceships of tomorrow. NASA actually wrote back! Can you imagine the effect a personal letter from the United States space agency had upon the starry-eyed dreams of a ten-year-old English schoolboy? NASA didn't just send one letter, but several. Books on what to study, and the skills needed to be a space engineer followed. Before I knew it I was applying to American universities to study Astronautics. Upon leaving school at 17 I obtained a scholarship, and after 5 years of study I received my Bachelors and Masters degree in Astronautics and Aeronautics from Stanford University. As a

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student I had been incredibly active in all aspects of the space program, and this activism continued through my professional career as an aerospace engineer. I have worked for several aerospace companies, and pervading all of my professional experience has been a frustration that the industry has lost some of the fire, the imagination,and the drive that had enticed me from England. Too many times I have heard the complaints of engineers and managers alike that the public isn't interested in space and there will be no more big projects like Apollo. This is hogwash! If Apollo could so move me to leave my home for the promise of a better tomorrow, then it could do the same for many others. I am here today representing the Apollo generation. We are coming home; the seeds planted by President Kennedy are now to be reaped. As a young aerospace engineer I resolved I had to do more than just engineering. I had to communicate the excitement that I felt, and likewise ignite the fire so evident in Von Braun's days. I began a crusade of selling the space program to the general public, to the students in the schools, to NASA, and to the aerospace industry. The results of that crusade have brought me before you today. I am still an aerospace engineer making a living by designing the spaceships of tomorrow, but the program I began several years ago is developing into a space corporation of its own. One day I hope I will be designing spaceships for it.

I am President of a citizen's supported, non-profit space corporation: Delta Vee, Inc. I emphasize the "citizen's supported" aspect of Delta Vee because our existence is one of the strongest demonstrations of support for an expanded, dynamic space program. The name Delta Vee results from a technical term meaning change in velocity. You will often hear space engineers talking about the "need for more Delta Vee". Plain and simply, we want to increase the speed with which we explore space. We feel that a corporation that involves the public in its activities is pivotal to an expansion of our current dormant program. Delta Vee is truly a space corporation of the people, for the people, and by the people. I represent over 15,000 people who have contributed their hard-earned dollars to help support NASA programs. As demonstration of their support I've brought along several thousand letters representing a sample of our constituency. I have entered some of their comments into the Record, but I would like an opportunity to read some of their comments to you. Before doing that, I should explain why we receive such letters, and why people are willing to send us their money and their ideas.

We are best known for being the corporation that successfully organized space interest groups, and the citizenry in general, to raise over $100,000 to keep the Viking lander on Mars operating. The Viking Fund was suggested to me by another English space refugee, Eric Burgess. Eric has been involved in space activities since the thirties. He helped form the British Interplanetary Society with Arthur C. Clarke, and most recently he was science advisor on the James Bond movie "Moonraker". This experience had obviously emphasized the entertainment possibilities of space exploration to Eric. During a discussion about the sad state of the space program, Eric suggested going to the public with the challenge to "put their money where their mouths are" as a way of revitalizing public interest and demonstrating support. In the same discussion Eric mentioned that funding for Viking was by no means secure, and that Viking would be an ideal test program to see if the public would pay for a project above and beyond their tax dollars. I took Eric's idea, and with the help of a small group of space engineers, students, and enthusiasts, formed the Viking Fund under the auspicies of the American Astronautical Society. The Viking Fund was announced in the May 1980 Omni Magazine, and Omni has been instrumental in publicizing and supporting the Fund's activities on a regular basis. Because of this and other kinds of support from magazines, companies, authors, boy scouts, science fiction fans, and the general public, the Fund has met with considerable success.

The basis for this sucess lies in the public's desire for direct participation in the space program. Until the Viking Fund came along, the public had to be content with watching the missions on the evening news, and perhaps writing a letter to you and your colleagues. The Viking Fund added a whole new dimension to space exploration - one whose implications we can only guess at.

One of the most significant achievements of the Fund's activities was the establishment of a working relationship with NASA. Historically, those of the space community who've tried to promote NASA'S activities have met with little cooperation from NASA itself. Initially, NASA was very skeptical about the Fund, and understandably so. Ask yourselves - how often do you hear of someone wanting to give money to the government? Persistence on the part of the Fund paid off largely due to the efforts of newly appointed NASA Director of Public Affairs, Brian Duff, and the late Associate Administrator for Space Science, Dr. Thomas A. Mutch. The stumbling block to a spirit of cooperation between NASA and the Fund was the infamous "unconditionality restriction". Briefly stated, this restriction said that anyone could give a gift to the government, but the government could not guarantee to spend the gift on what the donor requested the gift to be spent on. In a precedent-setting move, NASA removed the restriction by having the agency contract to the Viking Fund under a written agreement. The implications of this move are profound because it opens the funding door for many other needy space programs, and NASA is to be commended for its outreach and forsight. NASA's efforts paid off at a dedication ceremony at the National Air & Space Museum on January 7, 1981 where the agreement between NASA and the Viking Fund was formalized, and an intial $60,000 was transfered to NASA.

One of the other aspects of the Viking Fund which has immense significance is the diversity of its contributors. Everyone from 5-year-old children sending in their allowances, to 81-year-old ladies on social security, to unemployed people sending in part of their welfare checks, contributed. Every state of the Union was represented, and we received contributions from over fifty foreign countries. The contributors are there own best ambassadors, and I should let them speak for themselves.

> "Here is $5 for the future of our world. I wish I could give five million."
>
> "I have enclosed a check for $10.00 as a contribution to continue studies of Mars. It is my sincere wish that we, the concerned citizens of this country, can enable the exploration of space to continue through funds such as this. Good luck."
>
> "I believe the knowledge acquired and utilized by these efforts will benefit us all down the line and properly assure us of our future on Earth and in Space."
>
> "Research, in general, and space exploration in particular, should be a #1 national priority."
>
> "We have relied on quick-fixes to solve our problems too long; we must place direct and immediate effort into the long-term benefits and solutions to the Earth's grave difficulties that can only be found through space exploration."
>
> "I wholeheartedly commend and support your effort to promote continued progress in our space program. I believe it is time once again for the United States to show its leadership in development of space research and to reap the benefits such a program produces."
>
> "It appears that in our current state of lowered expectations and four-year policy perspectives, private funding of space exploration may have to become a major source of revenue."

> "I am beyond the age of thinking about traveling in space myself, but the children I come into contact with are not."

> "In honor of Ronald Reagan, We must go forward!!"

> "Can you hear us, Washington?"

> "If the government refuses to do anything about the future, then it is up to the public to do something about it."

Our Viking Fund activities will continue in an expanded fashion under the umbrella of Delta Vee over Viking's extended mission on Mars: an estimated fifteen years. However, looming at the edge of the Solar System is a new and demanding space funding challenge. Halley's Comet returns sunward in 1986, and it appears that the U.S. Government is willing to let this golden opportunity for scientific and technological progress go begging. At the request of many of the 11,000 Viking Fund contributors, Delta Vee has established the Halley Fund. The goal of this Fund is to provide a U.S. presence at the Comet. Fund raising is underway, and we are in the midst of the first phase of a national advertising campaign inviting the public, industry, and government to "Come Explore A Comet ... and Help Save Our Space Program Too". The response has been tremendous with over $40,000 being received within three months of our first call being made. It is obvious, as the following contributor's comments will demonstrate, that America wants to go to the comet.

> "I hope you receive many many more dollars, plus many BIG bucks from the short-sighted budget managers in Washington."

> "I find the government's reluctance to properly fund a first, and once in our lifetime, opportunity for a close look at Halley's Comet appalling."

"We hope, fervently, that the Halley Fund is a huge success."

"May we all one day see pictures from a comet's nucleus which these dollars have helped us achieve! More important -let's make the politicians hear us!"

"I'm a poor student. Here's one grassroot supporter for NASA and space exploration, so keep up the good work and go get them."

"Here's hoping we can save the Halley Intercept Mission."

Delta Vee has several other programs that make it unique amongst the spectrum of space-interest groups and aerospace corporations. We have an active advanced projects research group financed purely by citizen's contributions as part of our Ferdinand and Isabella Project Support Fund. In this Fund, we ask the average citizen to place themself in the specialized membership role of a Space Age Ferdinand and Isabella and suggest activities for Delta Vee. The most useful and well thought out suggestions receive several bonus thank you's including an all expense paid trip to see a shuttle launch. The Ferdinand and Isabella Fund is financing investigations of such advanced schemes as asteroid recovery, space based mirrors beaming solar energy to Earth, a new form of propulsion using chemical explosives, solar electric propulsion, and a host of other unique ideas.

Our first Space Age Ferdinand and Isabella travelled all the way from Ketchikan, Alaska to see the first launch of the space shuttle, Columbia. Jim's idea concerned popularizing the space program and the need for the public to have ready access to space merchandise. Jim suggested establishing neighborhood space centers in every city, small or large, that would be financed by the sale of pictures, books, slides, movies, and other "space- wares". These space centers would be similar to space "7-11 Stores", where, readily available on the street corners and in the shopping centers, are all the glories of the space program. Jim Tennant suggested the idea in April of 1981, and on September 20 of 1981, just five months later, Delta Vee's first neighborhood center was opened in a shopping center in the town of Los Gatos, California. Plans are already underway for similar centers in other communities, and we at Delta Vee take pride in the fact that in such a short time we have been able to take the raw idea of a member of the general public and turn it into reality.

Besides research and promotion, Delta Vee is actively engaged in educating the public about the benefits of space technology. Not a month goes by where one of our staff has not had the opportunity to lecture to a school or civic group about the wonders of the Space Age. Delta Vee's staff hosted the first Careers In Space conference in 1980, and we are in the planning stages of a major follow-up exposition to be held in 1982. Many of our educational services are provided free of charge to school and civic groups because of another aspect of Delta Vee: the sale of space related items. Known as our Space Wares division, our retail sales outlet sells all manner of pictures, slides, books, badges, models, and clothing to the public with the understanding that the proceeds go towards financing the space program through the mechanisms that Delta Vee has established.

Delta Vee has plans for several new Funds including one to finance the Search for ExtraTerrestrial Intelligence (SETI). Out amongst the stars there lies the answers to many of the oldest, most important questions facing humanity. We can eavesdrop upon the cosmos with our radio telescopes hoping to hear the conversations of other intelligent civilizations, and NASA has a program to do just that. It is called the Search for ExtraTerrestrial Intelligence (SETI), and the Earthly decision-making intelligence here in Washington D.C. has seen fit not to fund the project beyond 1981. Because of its Viking and Halley Fund experience, Delta Vee realizes that the public wants to see a search begun, and so Delta Vee has begun its Extraterrestrial

Connection: a public fund aimed at financing NASA's SETI program. Using its Viking Fund precedent, Delta Vee will contract with NASA for SETI research in the following manner: Most of the money raised will go for actual observations of probable stars, but a portion will be spent on upgrading search equipment to make observations more efficient so that a far greater number of stars can be searched in a given amount of time. Roughly $50,000 will buy a search program at the radio telescopes of Goldstone or Arecibo, and $1,000,000 will pay for improved data processing capability.

A natural follow-on activity to the Viking Fund is the future exploration of Mars. Many contributors suggested that the Fund initiate return-to-Mars studies, and the Viking Fund responded by co-sponsoring the Case for Mars conference. The Case for Mars was held at the University of Colorado at Boulder, May 29 - June 2, 1981, and Delta Vee is already planning another conference and summer study for 1982. The Case for Mars investigators concluded that a permanent research base could be established on Mars with little technological advance at budgetary levels not exceeding $3 billion per year.

Delta Vee, through the Viking Fund, the Halley Fund, Ferdinand & Isabella Project support fund, Space Wares, the Extraterrestrial Connection, and the Case for Mars intends to bring space down to the consumer level. We are convinced that the public is interested in space, and what is more, the public is willing to put "its money where its mouth is". There are millions of frustrated space supporters all across the world just waiting for an opportunity to do something for the space program. By providing a diversity of projects, Delta Vee hopes to reach those millions. We have made the first small step, and we are ready to take the next giant leap.

The next giant leap will see Delta Vee forming a profit oriented space corporation, AstroSpace, Inc. AstroSpace will undertake to actually build the vehicles of tomorrow using private financing resulting from investment, from the sale of space related merchandise, and hopefully from government contracts. AstroSpace hopes to change the way business in America and in space is conducted, thereby initiating a "goldrush" to space. Currently, this country builds space vehicles in a very unbusinesslike fashion. Spacecraft designers play the perpetual game of justifying the vehicle on the basis of the mission, and likewise justifying the mission on the basis of the vehicle. Inevitably vehicles without missions, and missions without vehicles are prime targets for budget cutting, and then nothing gets built or flown. An excellent example of this quandry exists in the Solar Electric Propulsion Stage (SEPS). Here is a vehicle whose propulsion capability will open up the Solar System for exploration and exploitation, and it has been killed each year, either by NASA or the President, for lack of a current priority mission. Yet no mission will become a priority as long as there is no SEPS. This catch-22 situation must end, and AstroSpace intends to break the deadlock by examining the building of a SEPS in much the same way as Boeing or Lockheed builds airplanes. We intend to approach investors with a private SEPS development proposal based upon the fact that if a SEPS is developed, there is over $2 billion worth of potential uses for it before the year 2000. If AstroSpace is successful, a fundamental stumbling block to the building of spacecraft will have been removed, and at that point an airline-type expansion of the space business may result. AstroSpace is confident of the saleability of SEPS because of the amount of mail that Delta Vee has received about future space exploration that in particular mentions SEPS.

Another giant leap for Delta Vee will be the eventual flying of ordinary people onboard the space shuttle. initially, members of the news media could be flown producing a Jacques Cousteau type documentary in space as a public education tool, and eventually ordinary people must be given a chance to fly in space. This may require the building of an extra shuttle, and perhaps this could happen by allowing advertising to be placed on the side of the vehicle in much the same way that high performance cars, boats, and planes receive advertising subsidy. To those of us that are used to doing business in the traditional aerospace fashion, this may seem like heresy, but space must be brought into the consumer arena if it is to expand to its full potential within the next twenty to fifty years.

In cooperation with Delta Vee, AstroSpace will form a partnership, a pipeline between the public, industry, and the government. Never before in the history of America has a business entity given equal priority to the three activities of research, education, and promotion, but Delta Vee and Astrospace are convinced that such an innovation in business is needed if we are to succeed in meeting the challenges of the Space Age. We have been given a mandate by the American and International public to pioneer the Space Age, and they have placed their trust in us by putting their money where their mouths are. As representatives of the people you too can "put your money where your mouths are". By working together we can establish unique incentives for private investment in space activities as well as cost sharing programs with the government. With almost no resources, all volunteer labor, and many sleepless nights, Delta Vee has grown from a club, to an organization, and now to a corporation. With your help there is no limit to the heights we can reach, and I welcome your involvement and suggestions in our enterprise.

Mr. FLIPPO. Thank you very much.

I would like to recognize the presence of the distinguished committee Chairman, Mr. Fuqua.

Mr. Chairman, would you have comments you would like to make at this time?

Mr. FUQUA. Well, thank you very much, Mr. Chairman, for giving me the opportunity. I want to commend you and the staff for having these hearings. We think about the last time we had thorough hearings on this subject was about 1975, and then 3 years later, in 1978 we did have some others. I think it is appropriate periodically to review where we are going and where our objectives are in space. I would like to commend the witness that just concluded, for the fine job that he and his group of volunteers are doing in promoting the space program. You have certainly been very diligent and forward thinking in the support that you have given.

I think you have demonstrated, as have others, through public opinion polls and public participation, that there is strong support for a well-balanced space program out among the people and the taxpayers and those that are willing to contribute.

I have even received checks and money orders in the mail from people which have been turned over to some of your funds, all from people who are willing to participate or to share in the space program. I, like you, become very frustrated sometimes when programs such as the SEPS and others are not carried forward.

While we have not had a specific mission for SEPS yet, I think it is time we proceed in an orderly fashion to develop that.

I must take one exception with what you have said. I am not sure that we always must have a mission defined in order to develop a propulsion system. When the space shuttle was developed, I don't think we had fully defined all the missions, and I am sure we have not today defined all the missions that could be used on that propulsion system and that vehicle.

It's the same with many other predecessor vehicles. We know what are the capabilities and what within those defined limits we can do.

I think we recognize that SEPS and similar capabilities such as the extended life of the Space Shuttle, are things that we must have in the future. Rather than have a mission specific that may have a time limit on it—rather than get into that paradox—it would be much better if we go ahead in an orderly fashion and develop the spacecraft we are going to need in the future—particularly SEPS—for interplanetary mission.

I have one question. What type of program do you see—the future programs that are essential that should be considered by this subcommittee and committee as well as NASA for, say, the next 5 or 10 years? What are some of the highest priority missions you outline? You mentioned some, maybe a return visit to Mars. Should it be manned, or should it just be unmanned with samples coming back? What other types of space missions do you think are essential for the next decade?

Mr. KENT. Backing up a little bit, I think your point about the mission mix and the vehicle is exactly the one I was trying to make, and if I didn't make it clear enough, that is what I wanted to do. We have to get away from developing propulsion on the basis of the mission. We have got to develop technology.

Mr. FUQUA. I misunderstood you, then.

Mr. KENT. That was the point I was trying to make.

When asking what future missions we should do, I think one of the things we have to do is take a look at the overall goal. I don't think we should make our space programs hang on any one thing.

The solar system is diverse enough that there are many things we can do. For example, if we had a Mars program, I think we shouldn't say it should be sending people or just robots. It should be a Mars program. There are certain first fundamental steps, like a Mars polar orbiter to search for volatiles. I think that we have to have a balanced program that not only looks, say, at the exploration of Mars, because that, then, gives us a chance to explore the asteroid belt; it gives us a chance to explore the outer planets.

One of the projects that is dear to my own heart, and I am mentioning it because it is my favorite program; we all have favorite programs—and that is SETI. I think that the public would really get behind the question: Is there anyone out there? We might never get an answer within our lifetime, but it is a small enough program that, begun here on the ground with radio telescopes, could have vast, vast returns.

Perhaps we could have a joint program. There are many, many radio amateurs out there who would love to get together in groups to operate small receivers and listen to all the frequencies that NASA could not. I would like to see that begun. But on a pure and simple level, on a basic philosophy, I think the future programs have to reflect diversity. We need a space station. We need an extended space transportation system. We also need to explore the planets. I guess what I am saying—and it may be like asking for too much in these current fiscal times—but we really have to have a true space program.

Mr. **Fuqua**. How do you answer the critics who say the planetary system has been there for many millions of years, and it will be there for many millions of years to come; so there is no time constraint on trying to examine the planets.

We hear that from critics of the space program, from some of our colleagues. We have to answer that question when it is propounded to us by colleagues. Why do we need a mission in 1985 or 1989, or some date specific? How do you respond to that type of criticism?

Mr. **Kent**. I think you respond by—it all depends upon the perspective from which you respond. If you view the space program as an expenditure, then it is very, very hard to justify the space program. You have to view it as an investment. The way I respond to that criticism is that the space program is one of the few Federal programs that actually makes money. There have been numerous studies that document dollar returns in excess of 10 to 15, for every 1 spent on the space program within 5 or 10 years.

Now, if I, as an individual, were putting my money into something and got that type of return, they couldn't keep me away from that type of investment. For some reason that is not clear to the critics of the space program, that it actually makes money. It makes us competitive internationally; it makes us economically and socially stable. It may not be a 1-to-1 correlation, but in the midst of the Apollo program, this country has never seen such direction and prosperity.

When we cut back, what happened? A lot of the youth lost vision. I, myself, am here today because of Apollo. I think that the attitude of, "Why spend money on space," is starting to disappear. Every time I go out and lecture, the number of people who say, "All right, I agree with you," or when I do a radio show, the number of people who say "This is a waste of money," are getting smaller and smaller and smaller. I think what we have to do is take the perspective that it is an investment and not an expenditure.

Mr. **Fuqua**. Of course, the other argument that critics use, is that this money, the expenditure of funds for the space program could be better spent on social programs to provide nutritious diets to students, we could build better roads, improve libraries and other things. How do you answer that?

Mr. **Kent**. I have a good answer for that one, because it comes down to what you are going to hear about this afternoon in terms of spinoff, but technology never progresses linearly. You cannot say that I need an electronic calculator, so I will develop it, or I need a particular food, so I will go develop it.

Technology proceeds in spinoffs. But the best example is, who is going to suffer the worst if we cut the funds for the space program? Certainly it won't be the engineers; certainly it won't be the companies. There are many things for them to do. It will be the poor who derive the benefits from a good economy. It will be the kids in the ghettos that perhaps, maybe just one of them, gets a vision to get out of the ghetto and to do something better.

We can't just take the attitude that space is food for the body. It is food for the spirit, also.

I think when you put it in those terms, and you show the space program does provide many social benefits—I hand people the NASA Spinoff book. I think if there is one thing this committee does, it should tell NASA to print more of those spinoff books. I don't care what anybody says, if they come to me and say: "Hey, the space program is a waste of money," if they are intelligent enough to sit down for half an hour and read that book, they walk away being convinced of the value of NASA, because you can pull out an example that gets right to someone's own personal belief system.

For example, oftentimes in San Francisco, where I live now, people say: "What is the good of the space program?" You point out the space program helped solve the cable car problem, the grip that holds the cable.

They will say, "Boy, I didn't know that." And that is the question, and that is what we have to answer: "Boy, I didn't know that."

So make sure you print more spinoffs.

Mr. FUQUA. Very well said. I might point out, too, that even a program like the Voyager program, which went to Saturn and Jupiter, and is now going out farther into the galaxy, carried no money in the vehicle. The money is all spent here on Earth.

Mr. KENT. That is a very, very good point. There is no cash register in space.

Mr. FUQUA. But, it is helping create jobs and technology and know-how with spinoffs that you outline.

Thank you very much, and I appreciate your being here and your support of the space program.

Thank you, Mr. Chairman.

Mr. FLIPPO. Mr. Brown?

Mr. BROWN. Mr. Kent, may I add my own commendation to you for the activities you have instigated through Delta Vee and the other organizations.

I am struck by your enthusiasm for a volunteer public participation in this program, and I am reminded of another volunteer effort in science, and I just wanted to ask you if you are familiar with it, and that is the MIRA program in Monterey where, in a voluntary effort by a group of young scientists there, they are doing their own astronomical research and putting up their own observatory in the mountains there in the Carmel area. It indicates, again, the willingness of the public to support an exciting concept which has no benefit except the expansion of man's horizons and the stimulating of his imagination.

When it comes to looking at it in hard terms, I think we have to recognize that there is a large and growing market, if we can use that term, for activities and ideas which stimulate the imagination of the public, and I think you are doing an excellent job in that aspect of stimulating the public's imagination. You nodded that you were familiar with MIRA.

Mr. KENT. Yes, I think the MIRA program and what we are doing typifies an attitude of do-it-yourself. If something isn't happening, don't get frustrated and moan and groan about it; do something. I think we have seen much more of that attitude pervading American and international society.

Mr. BROWN. For the record, I would like to indicate that MIRA is Monterey Institute for Research in Astronomy. It is privately funded.

I have no further questions.

Mr. FLIPPO. Mr. McGrath?

Mr. MCGRATH. Thank you very much, Mr. Chairman and colleagues. I am sorry I was late, Mr. Kent, and did not hear your entire testimony. I sometimes wonder why we are here talking about the future of space when the shuttle from LaGuardia Airport is 3 hours late.

I see in your testimony you have something to say about the Halley intercept mission, and you have a fund there to finance that. I am wondering whether or not you consider there is a better way for us to proceed on that rather than the one that NASA has outlined.

Mr. KENT. I think you have to look at what happens over the funding of the mission. If the Government is willing to fund it, I think there are ways we can reduce the cost. I think we have to examine ways to reduce the cost. I think the sharing of resources between the Government and the private sector is an excellent way to finance it, but I would like to leave no doubt in anyone's mind, I think the capability for doing this mission resides with NASA, with the Jet Propulsion Laboratory, and with some of the companies that have the expertise.

Mr. MCGRATH. What might be some of those alternative methods?

Mr. KENT. For example, one of the private companies, RCA, has made many overtures that they could use an existing spacecraft to go to the comet for dollar amounts of $125 to $150 million.

There are some bugs to be worked out with that. It is not a proven system. But—and this is the big "but" in the whole program—it is that type of money is entirely within the realm of private financing. If we look at what we spend on "for other"—"entertainment events"—it is very reasonable, a good example being when Mohammad Ali goes on TV and beats somebody up. The promoters can make $100 or $200 million in one evening, through syndications.

I will tell you there are more people out there that, if given the chance to have a close encounter with a comet in a theater, would pay $10 or $15 to see those live images. What I am saying is that might not be the best way to go, but if we have no alternative, if the Government isn't going to fund this, we have to look at other ways to do it.

I think it is tragic that unless the mission gets approved within the next 2 months, we can't go to the comet. That is a sad indictment of the way we are, because we went from having no launch capability to going to the Moon in 8 years.

We say we can't put one small robot problem together to go 140 million miles, to go and get pictures, something that we are the best in the world at doing. I think you really have to say, if we can't go to the comet, we may as well shut up shop right now.

I don't mean to be negative. That is not going to happen. I am convinced we will go to the comet one way or another. There will be a U.S. presence at Halley's Comet, and I am willing to consider all alternatives.

Mr. **McGrath**. What is the NASA estimate for the intercept mission?

Mr. **Kent**. The one that I am familiar with is around $300 million to $400 million.

Mr. **McGrath**. What is your estimate based on other alternatives?

Mr. **Kent**. Just in informal conversations with people in the aerospace industry who say, "Why does the space mission cost so much," if we are able to streamline and could have some of the redtape—some of the redtape is necessary, though—you could bring it down to between $300 and $200 million. That is a lot of redtape.

Mr. **Flippo**. Thank you, Mr. McGrath.

Mr. Kent, do you believe that private investment in our various space projects can substantially subsidize those projects? For instance, the Halley's program is about $300 million, and I believe you have received some $40,000 for the fund. Do you believe that volunteer contributions——

Mr. **Kent**. Not in total. Not in total. I think you have to look at a partnership. Well, let me back up. We have that $40,000 by having no Madison Avenue campaign. We haven't gone to the public like many of the slick Madison Avenue world of advertising does. If you did a campaign, that type, I think perhaps the limit that you could raise from the public is up to about $5 million.

I think if you really went out and did a public relations campaign with celebrities, and so forth, $5 million is the most you could raise for any particular concept where they were directly getting a benefit in return.

I think all you have to look at for the other type of financing is, how can we involve people, industry, who in the past have sat there saying, "What do I get out of it?"

One of the most ideal things that could happen is some sort of tax incentive for an industry that invests in space technology, or advance technology—something similar to what the Japanese and the Germans have done.

Mr. **Flippo**. What do you plan to do with the funds you raise?

Mr. **Kent**. What we are doing right now; we are pouring most of it back into advertising to raise public awareness. Part of it will go toward explorations of the comet, and if for some reason there is no NASA mission, one of the things that could be done is to pay for, say, high altitude observations of the comet with the NASA Learjet that is based at Ames Research Center.

I have one figure—that one flight would run $6,000. I think there can be very good ground-based observations of the comet. One of the nice things about that is, if we did that, is, since we would be the investigator, we could perhaps fly a member of the general public on the plane when they were making the observations as a way of saying thanks.

Mr. FLIPPO. Could you tell us anything about how large the grassroots support for the space program is and why the administration doesn't hear?

Mr. KENT. I think part of it has to do with the fact that you have to define what is meant by grassroots support. A great deal of it is closet grassroots support. Too many organizations, I think, want to own the space constituency lock, stock, and barrel. "You must become a member of my organization," is too often heard.

I think what you have to do is let people support the space program without selling their soul to a particular organization and that is why we met with so much success. I think literally the number of people who are willing to join an organization is in the 250 to 500,000 range. The people who support the space program—there are many statistics. I think one of the best ones is the Harris poll, which showed that two-thirds of the American public favored increased expenditures on the space program. One statistic I found the other day, is, on the Government Printing Office's list of books, 52 percent of the best sellers are NASA documents. That is 52 percent which are best sellers from an agency that sees less than 1 percent of the Federal budget.

Mr. FLIPPO. There are many reasons for a space program, Mr. Kent. One is military. The other is NASA's involvement in the civilian space effort. In times of severe budget constraints there are those who think we ought to continue the military and perhaps not continue the civilian agency.

I wonder if you would have an opinion, in the event this country lost its nerve or its will, or imagination with respect to a civilian space agency, what do you think would be the impact?

Mr. KENT. I think you are going to see frustration manifest itself. Certainly as an aerospace engineer I have worked on military programs, and I see a need for a strong military space program. But I also see the kids out there who want to get a picture, and perhaps if the civilian space program went away, there wouldn't even be as much ready information.

Let's face it; the public doesn't get fired up about reconnaissance satellites. The public gets fired up about Voyager spacecraft. They get fired up about the Shuttle. Even though the Shuttle will be used for military purposes.

I think the civilian space program is not going to go away. The public has not lost its nerve, and literally if the NASA program went away, I think you would see things like what you have heard about today, the Percheron project. You would see more of that, and you wouldn't just see launch vehicles; you will see people building satellites; you will see people taking the incentive and saying, literally, as one of the comments I read from a contributor: If the government isn't going to do it, we will do it, ourselves.

Mr. FLIPPO. Would you have any advice for us as to how we can better relate the benefits of space to the man on the street, so to speak?

Mr. KENT. I think one of the things we have to have is more national air and space museums around the country. have a space center in the towns where people can walk up and touch the technology.

One of the things that has to come from NASA are the books. It prints some of the most beautiful books and documents that any agency prints. The public doesn't see them. They say they will supply the pictures if the public requests them. They have the excuse, "We can't promote ourselves; we are a Federal agency."

Well, we are a private agency. We can. And we can go out at our own expense and give out those spinoffs. If more of those are readily available to us to set up at neighborhood space centers to make space available on the street corners, that is how the public will get the most benefit.

Mr. FLIPPO. Thank you, Mr. Kent. We very much appreciate your testimony. We are looking for ways to realize the future for space.

Mr. Hannah shows us that the U.S. private sector retains its spirit and that it will apply that spirit to space.

Mr. Kent has shown there is at least some strong popular enthusiasm support for space.

We are going to hear this afternoon about one kind of benefit to the space programs, and that is the spinoff in technology. We hope these hearings will be a step in developing a view of where we want to go with our space program. We appreciate your participation.

The subcommittee is adjourned.

AFTERNOON SESSION

Mr. FLIPPO. The subcommittee will come to order.

This afternoon we continue our hearings on the future space programs with what might appear to be a diversion: We are going to hear from three individuals who have successfully adapted NASA-developed technologies for use in other areas.

Mr. Joseph Pascente, president of Electronic Relays, Inc., a manufacturer of solid state relays, has developed a power factor controller which reduces the energy consumed by electric motors.

Dr. Donlin Long, chairman of the Department of Neurological Surgery at Johns Hopkins Hospital has developed implantable devices for monitoring pressures, relieving pain, and administering drugs.

Dr. Ronald Moskowitz, president of Ferrofluidics Corp., has developed the new technology of magnetically controlled fluids into a booming business.

Gentlemen, we look forward to hearing your success stories, but that is not our ultimate purpose. We want to talk about the future of space programs and so we want to learn how your successes can be repeated.

How can parallel efforts be started? What lessons have we learned? Has our success up to now been merely luck? Has the existence of a space program been irrelevant; that is, would the technology have been developed in any case? Are there new industries waiting to be born? What can we do to assist the process?

In other words, we claim there are great potential benefits. How do we realize them?

This is the way we would like to proceed, Mr. Pascente, we would like all of our witnesses to operate as a panel, to join us at the witness table and to present the testimony and then we would have some questions for the panel.

We would ilke to start with Mr. Pascente and then hear from Dr. Long and then from Dr. Moskowitz.

We are very pleased that you would take the time to come and be with us today. We are looking forward to your testimony. You may proceed. We will include your statements in total in the record and you may summarize as you deem appropriate.

[Biographical sketches of Mr. Pascente, Dr. Long, and Dr. Moskowitz follow:]

RESUME

JOSEPH E. PASCENTE

EDUCATION

1958 St. Patrick High School
Chicago, Illinois

1962 Christian Brothers College
B.S. Degree in Electrical Engineering

1965 Roosevelt University
Chicago, Illinois
Master's Degree in Business Administration

BUSINESS EXPERIENCE

1962-66 Teletype Corporation

Research Engineer in applied research in the development of new electronic systems. As a Project Engineer, in charge of overseeing the process of bringing new projects from the laboratory to the market.

Also responsible for trouble-shooting design problems in the field. That is, to go to a customer location where there was a problem with some of the Company's equipment and try to solve that problem.

1966-73 Grigsby-Barton Incorporated
Vice President for Research and Development

Overall responsibility for research and development work.

Also responsible for hiring of all management level personnel.

Later took on responsibilty for marketing, including the distribution and representative network and also in negotiating contracts with customers.

While with Grigsby-Barton developed and patented several new designs.

1973-76 Electronic Relays, Inc.
Vice President

1976 - present President

Responsible for all marketing. Also is company's representative in design conferences with customers who are in need of an originally-designed relay system to answer their problems.

Does all innovative design work.

OTHER

Holder of 11 U.S. Patents to date, with more pending.

CURRICULUM VITAE

NAME: Donlin M. Long, M.D., Ph.D.

DATE OF BIRTH: 4/14/34 PLACE OF BIRTH: Rolla, Missouri

HOME ADDRESS: 9 Blythewood Road
Baltimore, Maryland 21210

OFFICE ADDRESS: Department of Neurosurgery
Blalock 1408
The Johns Hopkins Hospital
601 N. Broadway
Baltimore, Maryland 21205

MARITAL STATUS: Married (Harriett Page Long)

CHILDREN: Kimberly Page, born 1961
Elisabeth Merchant, born 1964
David Bradford, born 1967

MEDICAL LICENSURE: Maryland 1973
Massachusetts 1965
Minnesota 1961
Missouri 1959

BOARD CERTIFICATION: American Board of Neurological Surgery, November 1968.

CITIZENSHIP: U.S.A.

SOCIAL SECURITY #: 488-38-3012

EDUCATION:

1951-52 Jefferson City Jr. College, Jefferson City, Missouri

1952-55 University of Missouri, Jefferson City Missouri

1955-59 University of Missouri Medical School, Jefferson City, Missouri
Degree: M.D.

1959-64 University of Minnesota Graduate School, Minneapolis, Minnesota
Degree: Ph.D.

INTERNSHIP:

1959-60 University of Minnesota Hospitals, Minneapolis, Minnesota
Department of Surgery.

RESIDENCY:

1960-64	University of Minnesota Hospitals, Minneapolis, Minnesota. Department of Neurosurgery.
1965	Peter Bent Brigham and Children's Hospital Medical Center, Boston, Massachusetts. Department of Neurosurgery.

MILITARY SERVICE:

1965-67	USPHSH, N.I.H. Bethesda, Maryland. Clinical Associate.

APPOINTMENTS:

1967-70	Assistant Professor, Department of Neurosurgery, University of Minnesota Hospitals.
1967-73	Neurosurgeon, Department of Neurosurgery, University of Minnesota Hospitals.
1970-73	Associate Professor, Department of Neurosurgery, University of Minnesota Hospitals.
1973 to present	Neurosurgeon-in-Chief, Department of Neurosurgery, The Johns Hopkins Hospital.
1973 to present	Professor and Chairman, Department of Neurosurgery, The Johns Hopkins University, School of Medicine.
1976 to present	Principal Staff, Applied Physics Laboratory of the Johns Hopkins University.

CONSULTANT:

1973	Baltimore City Hospital, Baltimore, Maryland.
1973	Columbia Hospital and Clinics Foundation, Columbia, Maryland.
1973	Loch Raven Veterans Administration Hospital, Baltimore, Maryland.
	Minnesota Veterans Administration Hospital, Minneapolis, Minnesota.
1974	Prince Frederick General Hospital, Prince Frederick, Maryland.
1974	Montebello Hospital, Baltimore, Maryland.
1977	John F. Kennedy Institute, Baltimore, Maryland.

AWARDS:

O.M. Steward Physics Award - 1953,54,55.
Outstanding Midshipman (NROTC Award) - 1953-54.
Medical Foundation Award - 1956-57.

HONORS:

Deans Honor Five (scholastic) - 1953,54,55,56,57,58,59.

SCHOLARSHIPS:

Curators Scholarship - 1953.

HONORARY SOCIETIES:

Phi Eta Sigma (Freshman Men's Scholastic Society)
Pi Mu Epsilon (Mathematics Scholastic Society)
Scabbard and Blade (ROTC Scholastic Society)
Omicron Delta Kappa
Mystical 7
Alpha Omega Alpha
Sigma XI

SOCIETIES:

American Medical Association
American College of Surgeons
American Association of Neurological Surgeons
Congress of Neurological Surgeons
American Association of Neuropathologists
William T. Peyton Society
The Society of Neuroscience
Electron Microscopy Society of America
Pediatric Section, AANS
Society of Neurological Surgeons
Cajal Club
American Association of Advancement of Science
Maryland Neurosurgical Society
Baltimore Neurological Society
International Society of Pediatric Neurosurgery
International Association for Study of Pain
Baltimore Chapter of Society for Neuroscience
American Society for Stereotactic and Functional Neurosurgery
Johns Hopkins Medical and Surgical Association
Society of University Surgeons

DR. RONALD MOSKOWITZ

Position: President, Ferrofluidics Corporation

Education:
PhD., Engineering, Rutgers University, 1966.
M.Sc., Electrical Engineering, Rutgers University, 1963.
B.E.E., City University of New York, 1961.
Engineering Faculty, Rutgers University and University of Mississippi, 1965-1967.
AEC Fellow, Princeton University, 1964.
RCA Fellow, M.I.T., 1963.
NSF Fellow, Rutgers University, 1964-1965.

Experience: Dr. Moskowitz is one of the two principals who founded Ferrofluidics Corporation in November 1968. As President, he is responsible for overall corporate operations. He maintains active involvement in technology, product and market development, finance and international business. He has guided Ferrofluidics through start-up and emerging growth stages to the present level of a public company with a transnational business base.

Dr. Moskowitz has been instrumental in the development of magnetic fluid seals, lubricants, damping, printing and other applications of magnetic fluid materials.

Prior to founding Ferrofluidics Corporation, Dr. Moskowitz was with Avco Corporation where he served as Manager of several different programs including microwave position control systems for the metal processing industry and a product line of nondestructive leak detection equipment. He had complete marketing, financial and technical responsibility for the development and introduction of these products to the industrial market. He joined Avco in 1967 as a Senior Consulting Engineer and simultaneously held an Adjunct Faculty appointment in the Graduate Engineering Program of the Lowell Technological Institute. During this period, he participated in the study of fundamental ferrohydrodynamic principles and the development of ferrofluid devices and systems. He was a codiscoverer, along with Dr. R. E. Rosensweig, of the ferrofluid vortex phenomenon.

From January 1967 to June 1967, Dr. Moskowitz held a Professorial appointment in Electrical Engineering at the University of Mississippi. There he taught and developed graduate courses in the electromagnetic behavior of material media. He supervised graduate research on magnetostatics and fine particle magnetic materials and was a member of the graduate advisory committee charged with developing the doctoral program in Engineering Science.

DR. RONALD MOSKOWITZ

From June 1965 to January 1967, Dr. Moskowitz was an Instructor in Electrical Engineering at Rutgers University where he lectured in network analysis, electromagnetic theory and electrical measurements laboratory. During this period, he assisted in the preparation of a new and novel text on electromagnetic theory which has been recently published, and served as acting chairman of the Research Seminar Committee.

From June 1961 to October 1967, Dr. Moskowitz was with the RCA Laboratories and Astroelectronics Division. There he conducted studies on stabilization and attitude control of artificial earth satellites and developed spacecraft magnetic attitude and momentum control systems. He was the principal investigator in the development of the magnetostatic method of spacecraft magnetic dipole moment measurement. Also during this period, he did orbit control studies on advanced meteorological satellite systems, consulted to circuit designers on properties of magnetic materials, served on design review boards and did research on fine particle magnetic materials and the physics of magnetic tape recording resulting in a computer simulation model of fine particle interaction phenomena.

Publications:

Secondary Applications of Synchro Devices: Vector, Vol. 25, p. 16, January 1961.

Measurement of Magnetic Multipole Singularities by Field Mapping: M.Sc. paper, Rutgers University, February 1963.

Magnetostatic Measurement of Spacecraft Magnetic Dipole Moment: (with R.S. Lynch), IEEE Transactions on Aerospace, 2, p. 412, April 1964.

Tabulation of Magnetometric Demagnetization Factors for Regular Polygonal Cylinders: (with E. Della Torre and R.M.M. Chen), IEEE Proceedings, Vol. 54, p. 1211, September 1966.

Magnetic Behavior of Single-Domain Particles: Ph.D. dissertation, Rutgers University, October 1966.

Computer Simulation of the Magnetic Dipole Interaction Problem: (with E. Della Torre), presented at 12th Annual Conference on Magnetism and Magnetic Materials, November 1966, and published in Journal of Applied Physics, Vol. 38, p. 1007, March 1967.

The Demagnetizing Field in Uniformly Magnetized Bodies of Revolution: (with E. Della Torre), IEEE Transactions on Magnetics, Vol. 3, p. 84, March 1967.

DR. RONALD MOSKOWITZ

Hysteresis in Square Loop Particle Arrays: Mississippi Academy of Science Annual Meeting, April 1967.

Hysteretic Magnetic Dipole Interaction Model: (with E. Della Torre), *IEEE Transactions on Magnetics*, December 1967.

Nonmechanical Torque-Driven Flow of a Ferromagnetic Fluid by an Electromagnetic Field: (with R. E. Rosensweig), *Applied Physics Letters*, 11, p. 301, November 15, 1967.

Magnetic Liquids Come of Age: *Electromechanical Design*, Vol. 17, No. 10, October 1973.

Magnetic Liquids: *Engineering Materials and Design*, Vol. 17, December 1973.

Designing with Ferromagnetic Fluids: *Design Engineering Division, ASME*, 1974, Design Engineering Conference, Paper No. 74-DE-5.

Dynamic Sealing with Magnetic Fluids: *Trans. ASLE*, 1974, Reprint No. 74AM-6D-2.

Magnetic Fluid Lubricants: ASLE 1974 Annual Meeting, Cleveland, May 1974.

Magnetic Liquid Vacuum Seals and Feedthroughs: (with W. Howe), *Proceedings SVC*, Detroit, May 1974.

What's New in Ferrofluidic Applications: *Research/Development*, Vol. 25, No. 5, May 1974.

Printing with Superparamagnetic Fluids: *TAGA, 1974 Annual Meeting Proceedings*.

Superparamagnetic Fluids: *INTERMAG Conference*, 1974, Toronto.

Magnetic Liquids...a new technology: *Solid State Technology*, September 1974, p. 44.

Nonwearing Ferrofluidic Seals: *1975 SAE Off-Highway Vehicle Meeting*.

Magnetic Fluids - Something to Consider: *Instruments & Control Systems*, October 1975.

A Review of Damping Applications of Ferrofluids: *IEEE Transactions on Magnetics*, Mag-16, 358 (1980), (with K. Raj).

Ferrofluidics

DR. RONALD MOSKOWITZ

Patents:	Magnetic Ball Bearing Assembly Using Ferrolubricants (coinventor), August 1976. Inertia Damper Using Ferrofluid (coinventor), October 1978. Dynamic Lip Seal Using Ferrofluids as Sealant/Lubricant (coinventor), October 1979. Ferrofluid Centrifugal Seal (coinventor), April 1980. Self-Activating Ferrofluid Seals (coinventor) - patent pending. Improved Self-Activating Seal and Method (coinventor) - patent pending.
Remarks:	Dr. Moskowitz is a member of Sigma Xi, Eta Kappa Nu, Institute of Electrical and Electronics Engineers, American Association for the Advancement of Science, American Vacuum Society, Technical Association of the Graphic Arts, American Society of Mechanical Engineers, and American Society of Lubrication Engineers. He is a Registered Professional Engineer in the Commonwealth of Massachusetts. In 1961, he was the recipient of the Maxwell Henry Memorial Award from the City University of New York. His biography appears in American Men of Science, Who's Who in Finance and Industry, Who's Who in Massachusetts, and Who's Who in Technology Today - 2nd Edition.

STATEMENTS OF JOSEPH PASCENTE, PRESIDENT, ELECTRONICS RELAYS, INC.; DR. DONLIN M. LONG, JOHNS HOPKINS HOSPITAL; DR. RONALD MOSKOWITZ, PRESIDENT, FERROFLUIDICS

Mr. Pascente. The success that Electronic Relays has been able to achieve in terms of technology transfer that has been passed on to it in the course of the last 4 years have been quite tremendous in the product that we have been able to capitalize on which has been a NASA invention.

One of the big problems that we see in the technology transfer is the association of this technology transfer to what most of—if I may refer to them as John Q. Public—everything they associate with NASA they associate with space vehicles and they have no conception as to what some of the other byproducts of the space program are.

If I were to put a number out I would have to say the ratio of direct space benefits as opposed to the indirect are probably of a ratio of 100 to 1. Because in the development of all these space vehicles, new technologies emerge and they are not so identified.

As a result of the minor changes in material, minor changes in electronics, minor changes in packaging, all come out as the result of the development of the space vehicle.

We received a power factor controller. This product had no bearing whatsoever on any of the space vehicles, but its benefit to mankind will be realized in the course of the coming years as being quite substantial.

I would almost think if somebody were to come out with a Nobel Prize in energy conservation that probably Frank Nola of the Marshall Space Flight Center should receive such an award in the course of the next few years.

Going back to the technology transfer, how could other industries benefit by our success, I would make a recommendation to this panel that some other media be used other than ITT who was the interface between NASA and ourselves at the time this technology transfer occurred.

I personally feel that organizations such as the NRDC, out of the United Kingdom, do a more effective job in terms of technology transfer. The kinds of technology that they are transferring out of the United Kingdom are probably—I use the word 100, again, in terms of significant values as opposed to what the NASA program has been able to generate. But that particular body goes out and actually does the total marketing in determining the marketability of the product and the concept and in doing so is more capable of identifying to those kinds of companies that could benefit by the receipt of this technology transfer.

Where in NASA—take for example the power factor controller. There are some 190 licensees and another, I think, 10 or 15 foreign licensees. These licenses have been handed out as if they were to be Crackerjack box coupons. If one were to go through the list, people would have been able to identify ex-NASA employees or even continuing NASA employees as some of the recipients of some of these licenses.

I say this because I have personally had an opportunity to call many of the licensees who are on the list made available to me and I question why this kind of technology can be handed out so freely without any concern as to what is going to be done with this technology because this technology was developed with Government money, utilizing Government employees, and, therefore, all the people in the United States and the rest of the world should take benefit of the result of this technology transfer and therefore my recommendation to the panel is that such a different kind of a committee—and I don't have the answers as to whether it would be, but I only refer to the NRDC because I had an opportunity to visit with them last month while in the United Kingdom because they themselves are now promoting an identical device which they claim is their own invention.

Mr. Flippo. For the record, would you identify the organization to which you refer, NRDC?

Mr. Pascente. National Research Development——

Mr. Flippo. In the United Kingdom?

Mr. Pascente. Yes. They are a Government body.

Mr. Flippo. Thank you.

Mr. Pascente. This organization is now selling licenses in the United Kingdom at $200,000 apiece and a 5-percent royalty. I have been told by their counsel that they have already sold 10 such licenses and they have 30 additional ready to pay this kind of a sum to receive this kind of a benefit, which I personally feel is no more than the extension of the NASA power factor controller.

I have been able to obtain from these people a copy of their patent applications, and I have forwarded them over to the NASA

Patent Council and they in turn will be in contact with this organization to advise them of what the patent position is.

Again, they have gone out and done a tremendous amount of marketing to determine the market for this particular product and after they have done so have then found suitable people who could then exploit this technology transfer, as opposed to the existing system which exists right now on just the power factor controller.

I cannot speak for other technology transfers because I have not been party to those except for one other done in a little bit different basis.

Looking at the market, looking at the kind of companies which should receive these kinds of technologies, I think the final coagulant that is lacking here is the profit motivation associated with this technology transfer.

Again, I don't have the answer to this and this is just a feeling on my part where, if this could be all narrowed together, I think more of the industry that sits out there will recognize what is really available to them.

When I tell people I have received from the National Aeronautics and Space Administration a free license, they look at me and say, "That free license therefore has no value because they are giving it away and since they are giving it away to 190 people, and most of them not even legitimate organizations or legitimate companies, then the rest of the industry looks at it initially as having no value."

Therefore, the value of what is being provided and what is being transferred is being lost by the method in which it is being transferred.

Mr. FLIPPO. Thank you very much, Mr. Pascente.

[The prepared statement of Mr. Pascente follows:]

ERI

ELECTRONIC RELAYS, INC.

1436 BROOK DRIVE • DOWNERS GROVE, ILLINOIS 60515-1092
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THE ECONOMIC SUCCESSES WE HAVE ALREADY SEEN

(1) WHAT IS THE FUTURE FOR SPACE PROGRAMS?

(2) HOW CAN TECHNOLOGY DEVELOPMENT PAY OFF BEYOND ITS FIRST TARGET?

(3) HOW CAN THESE LESSONS GUIDE US IN THE FUTURE?

The majority of American Citizens think of the space program as an opportunity for scientists to test many theories in the propulsion of vehicles into space to satisfy their own personal achievements as scientists. They do not realize that the space program has tremendous military, and social benefits as a result of the employment of these vehicles into space. These preconceived notions have led to tremendous opposition for further expenditures of monies into the space program. Unfortunately, space vehicles coincide with many of the movies that have recently been released such as "Star Trek" and "Star Wars", and the perception of the real benefits of these programs are not obvious.

Medical sensory devices as well as the integrated circuit are biproducts of the space program both direct, and indirect. Much of the indirect benefits of the space program are a result of scientists who have developed particular requirements for the space program and invented other nonspace inventions.

The United States has always been, to the rest of the world, the finest and the leader in technology. Within the last few years, this leadership, has been erroded by Japan and West Germany. The Governments of these other countries are providing tremendous research and development opportunities for small and large organizations. These types of benefits are not available to U.S. Corporations. One of the very few opportunities small and large businesses have, are the biproducts of the technology transfer as part of the NASA Space Program. Like all governmental programs to help society, there has to be a cost of benefit ratio. Take for example, unemployment. The cost of that benefit ratio is now determined as negative as opposed to the cost of benefit ratios which are directly and indirectly available as a result of the space program.

Besides employing talented scientists, these benefits help mankind in improving life support systems, and the value of life. I have recognized these benefits both in a general and specific nature. I have previously been editorialized in the Chicago Tribune on this subject matter, and have also written to various cabinet members, as well as to the President of the United States in my support of the continuation of these programs. I am the President of a small electronic component manufacturing company in Downers

Grove, Illinois which manufactures solid state relays. We have seen an editorial on the product called the Power Factor Controller which is a development out of the Marshall Space Flight Center. Its inventor, Mr. Frank Nola, who has done considerable work on the drive systems of the lunar module, developed this concept which had absolutely no bearing to the space program. As a result of the work that he was doing on DC motors, he invented what will be determined in the course of the next few years one of the most significant inventions ever to be released from the United States, the Power Factor Controller.

This invention has made available to all U.S. Citizens an opportunity to reduce the energy used by electric motors. The Power Factor Controller reduces the amount of energy that is being consumed by electric motors without altering the performance of the electric motor. The electric motors in the United States consume more units of electrical energy than the American automobile. Any savings associated with the use of electric motors is going to reduce our dependence on all forms of energy.

The Power Factor Controller is so significant, that other countries are attempting to claim patent positions. For example, the NRDC of the United Kingdom, is at this time touting their invention, which is no more than a copy of Marshall Space Flight Center's invention. Their claims are an extension of the existing Power Factor Controller, but their writings and publications and publicity are proclaiming significant energy savings throughout the world. As an American Citizen, I find it horrifying to have the opportunity of our own scientist developing such a significant invention, and not even having the opportunity to protect this invention in the matter where the United States shall maintain its leadership in terms of technology.

I urge this panel of esteemed representatives to reconsider any possible reductions in the space program, for its benefits both direct and indirect will provide to the American Citizen continuing benefits.

Mr. **Flippo**. Dr. Long, would you give us the benefit of your testimony, please?

Dr. **Long**. I would really like to make two points, and I will only summarize my written statement about the first. Both relate to the way technology can be transferred from physical sciences into biomedical sciences.

The first is what has been happening up to the present time and that is simple technology transfer, the discovery of one technology and the appreciation that it may be useful in another area.

Now, we have given three examples of the way this can occur, from the interaction of a very small group of people at our applied physics lab and in the Department of Neurosurgery at Johns Hopkins.

The first of these was the development of an intercranial pressure monitor which was telemetered. This is simply a way to measure the pressure inside the head.

In many situations it is critical for the patient's survival that this be known and controlled. The techniques known before were very simple: tubes or diaphragms or something very simple that could be used only for a short time, a few days, because of the risk of infection.

The device that came from the space technology program can be implanted inside the skull through a simple operation. It can stay in place for days or weeks or months or years if you want and provide a constant monitor for pressure.

The second of the techniques that we have employed relates to electric stimulation of the nervous system. We have used it primarily for pain, but it has other applications as well.

The stimulation of the nervous system is old hat. Now, it has been around for 10 years and it is reasonably effective, but the techniques have not been improved since 1965 to 1967 when they were first introduced. This new technology allowed us to build a simulator which is totally inside the body. No wires and contraptions that have to attach the patient's body as the older devices used. It gives a much broader range of electric stimulation, so for the first time we can really explore the effects of stimulation on the nervous system in a human who can respond to it. We think we will learn a great deal more about stimulation in this way.

Finally, it has some very practical advantages for the patients. When the whole system is complete it will be telemetered by telephone. You can interrogate it by a computer to determine how it is functioning and if it is not working, why not.

This is particularly important because these kinds of things are done in only a few places in the United States. Patients are often hundreds of miles away from you and they make many useless trips over a broken wire, a defective battery, or something equally simple.

Now, the third area where we have taken part in this direct technology transfer is in the development of a device that is still very experimental. We hope to have our first patient trials sometime this fall. This is an implantable drug infusion pump. It is a miniature computer that should allow us to deliver any amount of drug on any schedule into any body cavity that we wish over a long period of time.

We originally devised it to try to treat cancer pain by giving small amounts of narcotics right into the spinal canal, by the spinal cord, hopefully obviating addiction and side effects of the drug.

It has other uses such as delivery of insulin for diabetic, blood thinners for heart and stroke patients, and seizure medication for epileptics. There are others, but those are the ones under immediate study.

This kind of thing is all very worthwhile, and I am very pleased with the cooperation we have gotten from everybody in developing them, but these kinds of interactions are almost accidental. They occur because the technology is developed for another purpose; someone looks at it and says, "I can use that," and tries to make the application.

The second point I would really like to make is more important and fits with the last part of your charge. That is we ought to be able to do a much better job by some forward planning.

What I think is necessary is some kind of amalgamation of the physical scientist through the NASA program and the biomedical scientist to make some plans, to set priorities, and to look for problems and potential solutions before the research actually begins rather than waiting until after it is over and hoping that someone comes out of the project.

Now, within that framework I think we need several things that aren't really in existence now. One is a mechanism to define what will be the most important national problem. Another is a way to really let everyone in biomedicine know what the technology of the space program is and where it can be used.

A third thing is to get industry involved because I think the weakest link in this chain has been the move from the development of the device to the practical application to large numbers of patients.

That is especially true because there is no good way to get the funds to do the long-range patient studies necessary to test and perfect these kinds of devices.

I think we need more training of people in this very specialized field. It is not common to find people that can understand both languages, and I think we need some training to develop this kind of individual.

Finally I have a pet project. There are high risk but potentially high pay fields that can be studied effectively. High risk in that they have a high possibility of failure, not because they are dangerous to anybody.

It is very hard to get that kind of project funded. It often takes a very long time and the risk of failure frightens most kinds of funding agencies.

I think any new program really has to incorporate that kind of research project as well.

I really think the point I want to make most forceably is the one of planning. I believe the most important thing to come out of this kind of meeting is some kind of amalgamation plan for prospective studies in this high technology transfer.

[The prepared statement of Dr. Long follows:]

THE JOHNS HOPKINS HOSPITAL
601 North Broadway
Baltimore, Maryland 21205

DONLIN M. LONG, M.D.
Professor and Chairman

Department of Neurological Surgery
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SUMMARY FOR TESTIMONY FOR HOUSE OF REPRESENTATIVES

Biomedical Engineering as related to neurosurgical practice has benefited significantly from the technological advances of the Aerospace program. Collaberation between the Applied Physics Laboratory of The Johns Hopkins University and The Department of Neurosurgery of The Johns Hopkins Medical School has resulted in three systems which have immediate patient application and represent significant advances over anything previously available. These are 1) A telemetered intracranial pressure monitor; 2) A completely implantable telemetered nervous system stimulator and 3) A completely implantable drug infusion pump.

1) The intracranial pressure monitor

Head injury is one of the major causes of mortality and morbidity in the United States. Approximately fifty-thousand people per year are killed in automobile accidents alone and sixty percent of all accident victims suffer from significant head injuries. Increase in the pressure inside the head is a major cause of mortality and morbidity. Most of the treatment of head injury is directed at control of this pressure. Until the recent past, the only way to monitor the pressure level was to place a rubber tube through the brain into the fluid filled spaces deep inside or to place a metal device through the skull into the space surrounding the brain. Utilizing the latest technological advances of the Aerospace program, biomedical engineers and neurosurgeons at Johns Hopkins have produced a telemetered device which can be implanted in the skull through a minor operation. The pressurecan then be read continuously or intermittently by a monitoring device outside the body. There is no need to have anything attached to the patient. The technique is simple and the fact that nothing is coming through the skin reduces the risk of infection. It is not necessary to place any needle or tube through the brain so the technique is significantly safer, as well.

It has now been modified to allow the study of elevations of intracranial pressure in other diseases. Patients with tumors and children with birth defects can be studied and treated using these techniques.

2) A telemetered programmable human tissue stimulator for the control of pain

Electrical stimulation of the nervous system for the control of pain has been a reality for approximately ten years. Patients with the most serious kinds of pain are often candidates for devices which are implanted inside the body to stimulate nerves, spinal cord or brain. Until recently, all of these devices had to be in two parts. One part was implanted completely inside the body and a second part containing the battery or power supply was outside. The outside portion had to be attached to the skin immediately over the implanted part of the device. Utilizing pacemaker technology, which is a direct result of involvement in the Aerospace program, we have developed a stimulator which is self-contained and can be implanted totally within the body. The battery is rechargeable through the intact skin so nothing has to be applied to the skin externally. Such a system does not necessarily provide better pain relief than existing techniques, but it has several major advantages for the patient. First, there are no external wires which have to be attached to the body. Secondly, the telemetry feature means that the physicians involved in the patient's care can change what the stimulator is doing without reoperation. Several electrodes can be implanted which means that the patient and physician can change which electrodes are being used. This may salvage the function of a stimulator which is not working well and prevent reoperation. It is also possible to change the electrical stimulation parameters. It is frequently possible to make a stimulator more effective simply by changing the way it is stimulating. This is possible to do by computer. When the system is complete, it will actually be possible to do it by telephone so that patients will not have to make trips back and forth to the hospital or physician's office to have changes made. This is particularly important because these kinds of devices are used only in a few centers in the United States. Patients often have to travel long distances to have them implanted and then are faced with multiple return trips for minor adjustments. The techniques also allow continued investigations of the best forms of electrical stimulation for optimum pain control and represent a completely new capability for research in this area.

3) An implantable pump for drug infusion

Using the same technology which developed the totally implantable human tissue stimulator, we have also developed a completely implantable drug pump which is ready to begin human testing. This pump is a miniature computer which calculates the proper dose of a drug and delivers it each day to the patient. The device is implanted into the body through a relatively minor surgical operation. It is charged with the drug through the skin by means of a needle. Patients who have to take drugs for long periods of time can then obtain them on a regular basis without concern. The kinds of patients who are most likely to be benefitted immediately by such a system are diabetics, where the need for daily subcutaneous injections of insulin could be eliminated, heart and stroke patients who need to take blood thinning medicines on a regular basis and cancer pain patients who need to take narcotics. This application is the one in which we, in the Department of Neurosurgery, are involved. It has been shown recently that cancer pain, in certain situations, can be relieved by injecting very small amounts of narcotics around the spinal cord.

It appears that pain relief is much more satisfactory and that both addiction and side effects can be greatly reduced by this route of administration. It is not practical to do these kinds of punctures on a regular basis, however. Utilizing the pump, it would be possible to have the machine deliver a small amount of narcotic daily near the appropriate area of the spinal cord and good, long lasting pain relief can be obtained. It is too early to tell whether the technique will be of value for chronic pains other than cancer, but the data is already available to indicate that it will be a useful technique in the management of cancer pain.

The development of all of these devices is a direct outgrowth of the Aerospace program. We believe that these prototype devices are only a beginning and that through the application of this kind of biomedical engineering, we can greatly improve patient care in the field of neurosurgery.

Mr. FLIPPO. Thank you very much, Doctor.

Dr. Moskowitz?

Dr. MOSKOWITZ. Mr. Chairman, honorable members of the committee, I welcome this opportunity to appear before this committee to tell the Ferrofluidics' story and to generalize some conclusions about the way we might create future companies such as Ferrofluidics.

Ferrofluidics Corp. was founded approximately 12 years ago to develop an exciting new technology—the technology of magnetic fluids that has roots directly traceable back to NASA/Lewis and which recently was the subject of an article in a NASA publication, "Spinoff." We have attached this article to our written testimony.

I don't intend to precisely follow the written testimony today, but to illustrate with the use of some slides and some materials and then attempt to generalize some opinions and conclusions.

The hardest part of all will be to do this within the 15 minutes allowed. I might start by passing out a sample of a ferrofluid and a magnet.

What I have passed about is a sample of magnetic fluid. There are actually two fluids in the bottle, one of which is magnetic and one of which is nonmagnetic.

We have arranged the chemistry so the black magnetic fluid—the clear fluid preferentially wets the wall so you can see the magnetic fluid and how it leaps to the magnet.

It is this ability to position and control fluids by remote means that provides engineers with a powerful new tool to create literally waves of new products.

We think that the things we have done thus far are really just the tip of the iceberg.

Now, what is this ferrofluidic technology and what are ferrofluids?

[Slide.] In this first slide we are looking at fluid spikes, they look more or less like chocolate drops, in this case, as amazing as it may sound, the fluid is falling up.

We have used the magnetic fluid to create an interfacial instability and the fluid is literally falling up. It stays quite liquid in this condition.

This happens to be one of the phenomena for which we have not yet found an application.

[Slide.] Here we see another example of fluid being positioned and controlled. Here is fluid in otherwise free fall, but the magnet that you see on the right is causing a magnetic field to act on the fluid and deflecting its course of fall.

[Slide.] Here we see a very interesting phenomenon which is called levitation. On the left we see some fluid in a vial and into the fluid has been dropped a dense ball which does what you would expect it to do in a liquid: it sinks. But when we bring that same fluid in the vicinity of a magnetic field, the fluid is pulled down; the ball, being nonmagnetic, is therefore levitated and what we are seeing is literally an antigravity phenomena, a levitation against gravity by indirect means using the magnetic fluid medium.

This has important applications.

Another general phenomena is that of damping. Fluids have been used for many years in many types of damping devices. Most obvious are the shock absorbers on your car.

Here we see containerless damping. You no longer need the shock absorber casing. You hold the fluid magnetically where you want it, opening this up to meter movements including the speedometer on your car and in common, everyday devices such as electromagnetic drivers and motors.

[Slide.] Another example of the phenomenological use of the fluid is a pressure holding capacity. Here we position and hold the fluid, in this case in a ring around a shaft. That is the black belt shown here. Around all of this business is a magnet and a couple of focusing structures which are not contacting the shaft, just creating a very intense magnetic field and that, incredible as it may seem, has enough strength to hold that fluid in place with such force that you can literally destroy the mechanical hardware before the fluid would come out. Thus creating a zero leakage, zero wear, and sticktionless (zero sticking friction) seal which is a powerful new tool in sealing technology.

A bit about the company. Ferrofluidics Corp., as I indicated, was founded 12 years ago and we have struggled for 8 years before we broke even in trying to develop applications and markets for this technology. It was very much a solution looking for problems.

Today we are a rapidly growing high technology company. This is our new plant that we built and took residence approximately a year and a half ago. At that time we had 35 employees. Today we have 110 direct employees and about 200 people working indirectly for us through subcontractors for a total of 300 jobs being created in America. That growth has occurred within the last year and a half and is expected to approximate that rate for some time.

[Slide.] One aspect of Ferrofluidics Corp. is the continuing dedication to being a materials company. Here you see an analytical lab. We are a specialty chemicals company making state-of-the-art magnetic fluids.

We are never complacent and are constantly working on a next generation looking for fluids of extremely low vapor pressures or higher magnetization or higher viscosity properties that our customers' applications may demand.

[Slide.] Here you see a range of sealing hardware such as we supply to the semiconductor industry, one of our two prime markets. These products are used in process equipment which is used to make microprocessor chips and semiconductor devices. They are made by various deposition processes, generally in a vacuum, where sealing is absolutely critical.

Here they talk about leakages in terms of how many molecules got into the system to contaminate the process.

[Slide.] Here you see an extension of that sealing technology into subsystems. This is a complete rotary lift system used on crystal growing furnaces to make monocrystaline silicon.

That is the starting point of today's semiconductor devices, forming the basis of the substrates on which chips are made.

[Slide.] Here you see a pull head assembly for crystal growing furnaces which also take advantage of our sealing technology.

[Slide.] Here you see about a 2-foot-long ingot of monocrystalline silicon such as would be grown in the silicon growing furnace. Because of the great importance of our sealing technology in this particular application area.

[Slide.] Ferrofluidics Corp. recently acquired the technology and assets of Varian in its silicon crystal growing product line.

Here you see a crystal-growing furnace in operation with an operator looking through a quartz window at the process. It is conducted at about 1,400 degrees centigrade and rotation must take place very precisely at the ingot and the quartz crucible that holds the molten silicon.

This shows a typical silicon crystal-growing furnace of the present, such as the technology we acquired.

[Slide.] This shows a very large furnace. This same technology that is used for semiconductor processes is used in the solar industry to produce photovoltaic cells for direct electricity from the sun.

A furnace such as this would create large amounts of silicon in an inexpensive way.

[Slide.] Here you see an artist's rendering of a new furnace imminently about to be introduced into the marketplace by Ferrofluidics Corp. This furnance utilizes the latest generation of sealing, as well as many other innovative processes.

You can see the process of vertical integration of our technology into equipment and products needed in the marketplace but, again, based on the fundamental ferrofluid technology.

[Slide.] Here you see a typical memory disc drive. Here the operator is about to load and place the computer disc pack onto the drive assembly for the computer.

[Slide.] This is the spindle on which that disc pack sits. You don't normally see this spindle even if you have seen disc drives and this is an exclusion seal for the disc drive which Ferrofluidics supplies.

Another major market of ours is the computer peripheral industry and this seal gets sold to the people who make those spindles who might be disc drive manufacturers or might be vendors of theirs.

It sits in the top portion and prevents atmospheric contaminants as well as barring lubricant vapors from entering that disc drive cavity.

The importance of this technology is such that during the last few years, we placed into service about 1 million seals and the rate is rapidly increasing.

[Slide.] Here you see another important application of our technology, which is in loudspeaker drivers. You see two identical drives which have been exposed to a DC level input and in one case, it is showing 228 degrees and the other is showing 85 degrees and the only difference is the one showing the lower temperature has ferrofluid in it. You are witnessing a liquid cooled loudspeaker driver.

[Slide.] Here you see ferrofluid being injected into a woofer which is the largest of the typical loudspeaker drivers, giving the bass sound. It is a very simple operation.

All the magnetics are already there to retain the ferrofluid. You just have to figure out what is the right fluid to use to accommodate this incredible level of temperature protection.

[Slide.] Finally, here is another important application of our technology. It is in what is called an inertia damper. Many computer peripheral equipment have stepper motor drives. Such as computer printers that have paper-advance mechanisms or head positioners on floppy disc drives or just about anywhere you want to have discrete digital motion.

This slide shows a representation of a stepper motor typically driving some type of load. The problem with these things is they suffer undesirable vibrations and hunting about a final equilibrium position that consumes time. A very attractive way of damping is by using inertia dampers.

Here is a Ferrofluidic inertia damper making use of that levitation property. It is virtually indestructible because the fluid not only is the damping medium, but is the bearing, itself.

[Slide.] Here you see the difference in performance of the device without the Ferrofluidic damper and with the Ferrofluidic damper.

In the first case, you see all these isolations about the fine equilibrium motion.

Second, you see a rapid overshoot and then a final hunting about equilibrium position.

[Chart.] Similar on an oscilloscope trace.

[Chart.] We will now talk about some future potential applications in technology. I think you can see that here is a technology that not only has some very fundamental phenomena much of which is even yet untapped, and a company which has reached a rapid evolution in a commercial stage, but we are also talking about a technology that has some very exciting potentials for society in terms of the applications.

[Slide.] Here is one such application. This slide was provided through the courtesy of the U.S. Bureau of Mines, which is doing work using magnetic fluids in densometric separation of media.

Here you see a mix of scrap coming in on a conveyor into a large pool of magnetic fluid held at an angle. Two other conveyors are also shown. By applying a magnetic field to that large pool, the denser materials sink and the less dense material floats. You can position the magnetic fluid with an intermediate specific gravity to get separation of the sink and float material. You can separate automotive scrap, various kinds of mining ores and so forth. It is actually being used today in the separation of diamonds from rock.

[Slide.] Here you see the magnet and the pilot plant at the Twin Cities Research Center in Minneapolis. Here you see the conveyor coming out dumping the one material out here and I believe that is the other, there.

[Slide.] Here you see the actual floatout materials coming out with the ferrofluid.

[Slide.] Here is another representative example of the future. This happens to show a brain aneurysm located in a skull. These pictures were provided courtesy of Dr. Roth, a neurosurgeon from Harvard University.

[Slide.] This is a concept that I believe he developed. There have been several researchers in this field doing work of this type, which was to inject a magnetic fluid in some vein location, let it flow through the artery system and then position some magnets, needle magnets at the base of the aneurism so as to seal it off—an aneurysm is a weakening of the arterial wall.

If you can release the pressure on that aneurysm, the body will literally cure itself. That is the basic concept.

[Slide.] Here you can see a surgical procedure in which some needle magnets were literally sutured in place. That is the actual aneurysm right there. This was also some experimental work. I don't have time to go into the various stages of evolution this area has progressed through at this time, but there are many examples of medical application on the horizon.

[Chart.] Then we have lubrication. What is lubrication, but getting oil in the right place to which we go to great lengths, one way we handle this is by making greases, just in the hope of getting a little where you want it.

We can now position the lubricant exactly where we want it, tell it where to go and where to stay.

[Chart.] The whole area of sealing is virtually untapped. We have talked about semiconductors and the computer peripheral industry. This is a high-speed seal which is applicable to all kinds of machinery such as compressors and blowers.

There are many industries such as the chemical industry that will yet benefit from the applicability of this zero leakage sealing technology.

[Slide.] Here we have an example of an application in the energy field. There were many applications but this one incorporates again that levitating principle. We have proof masses here in an enclosed hollow cylinder which has various types of capacitive markings so that we can electrostatically detect the location of the proof mass which is magnetically levitated in a ferrofluid film inside that device forming, therefore, an incremental velocity sensor or accelerometer.

Originally this was looked at for the Air Force in avionic devices for those types of systems. It has been currently developed in well-logging applications in the oil industries.

When they drill, they don't go straight down. They start in one central location and move in different directions. This device is currently being used.

[Chart.] Here, again, is an application of enormous potential. What is being held in the hand here is a bearing that is on a fluid film. It is actually what we call a hydrostatic bearing operating on an air film and a fluid film, so the fluid is supporting some of the load as is the captured air that is permanently captured here.

There is no friction of any kind. It is totally passive, there is no wear. I heard one of the earlier speakers talk about energy reduction. There is enormous potential here for energy reduction in machine elements of all kinds and improved performance of various types of devices as well.

[Slide.] In this particular slide, you are seeing that very bearing and here we attached a feather to it. Just the thermal currents in the room—this is sort of an exposed-length photography and the currents in the room are enough to sway that feather around almost continuously with just a minor flow of air near that bearing.

There is absolutely no sticking friction.

I think it is very clear that our corporation represents the kind of company that we need more of in this country. There is a lot of innovation, there are a lot of new products now and into the future.

We are creating jobs in large numbers at this time. We are paying taxes, fortunately, in the last few years and we are exporting substantially, too; 30 percent of our products were exported in the last quarter and that is expected to increase. We project in 5 years, over half of our products will be exported, providing the Department of Commerce doesn't change the game rules.

The question that I believe is really before us is how do you replicate this? Are we a fluke? Are we a random occurrence that is not going to reoccur or are we something that really can be replicated and if so, how do you force-feed the system, so-to-speak?

Do you get lots of these things? As a citizen, I would like to see 10,000 such companies, hopefully not exactly like ours.

That is what I think would be the best thing for our country.

I believe the prime issue is in innovation. You need innovation. There would be no ferrofluidics today if there was not that innovation.

That is no guarantee that if you have the innovation that you get a ferrofluidics. There was an awful lot of blood, sweat, and tears that occured between that innovation and the ferrofluidics of today.

Nevertheless, you don't get it without innovation and I think that is the vital issue. You need innovation. I don't believe you can plan innovation. I think there has been a lot of work in this area. It is my opinion you cannot plan it. However, it does result as a byproduct of major human undertakings.

Very frankly, gentlemen, war happens to be one of those undertakings and I think we can look back to World War II and World War I as periods of intense technological activity.

I don't know if General Patton actually made this statement, but it is attributed to him in the movie by that name. I think he said that war leads to the greatest creativity and advancement of mankind.

Well, gentlemen, that may be the case, but I am not encouraging that we go to war to achieve our objectives.

There is another way, and I believe that the space program has been that other way. The objective of putting a man on the Moon. I will tell you I was a young engineer at RCA—Astroelectronics Division in Princeton, N.J., and when President Kennedy said he was going to put a man on the Moon in 10 years, even I didn't believe him, but sure enough, we did do it and it was an exciting period of time and there was an awful lot of innovative fallout.

I believe we are part of that fallout. Ferrofluidics of today. But I think one of the problems that we have as Americans in our entire system is that we do not take a long-term view of anything.

We don't give things enough time. It has taken 14 years for ferrofluidics to get to the point it is today. That was with incredibly intense activity.

These kinds of things take 20 years. If we are not making the investment today, where will we be in 20 years?

I believe we need the space program. I can't think of anything else quite like it, other than war, or some similar activity which can lead to the kind of innovation fallout that I am talking about. But, we also need to measure things not in the period of one presidential administration or what would be one congressional term of 2 years, but rather, in terms of 10 years and 20 years, anyway, for these kinds of things to benefit our fellow Americans.

It is my considered opinion that this country's ability to create new technology and manage these innovations into productive new industries will determine the future wealth of the Nation and its continued position as a world leader, and I believe that position is not guaranteed in the future, not commercially and not militarily, unless we take these kinds of actions.

It is my conclusion that we need a driving force that creates a seedbed of innovation and that the space program has been providing and hopefully will continue to provide this driving force.

Thank you very much.

[The prepared statement of Dr. Moskowitz follows:]

STATEMENT BY
DR. RONALD MOSKOWITZ
BEFORE THE SUBCOMMITTEE ON
SPACE SCIENCE AND APPLICATIONS

U. S. HOUSE OF REPRESENTATIVES

Mr. Chairman, Honorable Members of the Subcommittee on Space Science and Applications, I welcome this opportunity to appear before the committee to discuss an economic example of the space program's beneficial spinoff process.

Ferrofluidics Corporation was founded slightly more than 12 years ago to develop proprietary products based on an exciting, new technology that originated with NASA/Lewis. The Ferrofluidics story was recently told in some detail in SPINOFF 1981, a publication of the National Aeronautics and Space Administration, a copy of which has been attached for your information along with five illustrative photographs.

FERROFLUIDIC TECHNOLOGY

It would not surprise me if you do not recognize the word "FERROFLUID". Few people do. Ferrofluids, which are magnetically responsive liquids, do not occur naturally and, therefore, only a very small percentage of the population has actually ever seen these unique, new materials. A sample of a typical ferrofluid will be passed around for each of you to observe first-hand the behavior of a magnetic fluid when controlled by a simple magnet.

Ferrofluidic technology is far more fundamental in its implications than the magnetic fluid that you will witness leaping toward the magnet. Some have drawn an analogy between magnetic fluid technology with the comparable early stages of laser and solid state technologies in terms of the broad range of applicability and ultimate benefit to industry and society.

To view ferrofluidic technology in the proper perspective, one must realize that:

> FOR THE FIRST TIME IN HISTORY, AN EXTERNAL FORCE OTHER THAN GRAVITY OR MACHINE ACCELERATION CAN BE EXERTED ON A FLUID TO CONTROL ITS POSITION...AND THAT PLACES A NEW TECHNOLOGY AT SOCIETY'S DISPOSAL...WITH BROAD AND FAR-REACHING IMPLICATIONS.

We shall not today have an opportunity to cover all of the fundamental phenomena that ferrofluids make possible, or the extraordinary range of applications that the technology has been finding; however, we can illustrate our points with several representative examples.

Positioning. Ferrofluids can be held in precise position by a magnetic field gradient defying the force of gravity. This controllable phenomenon opens exciting new possibilities for imaginative applications. We have used this phenomenon to develop a proprietary rotary seal that has ABSOLUTELY NO WEAR AND NO LEAKAGE. The ferrofluid is the actual sealing element held in place around a rotatable shaft by magnetic forces generated in a stationary seal assembly.

Fluids have long been used for damping of vibrational motion such as in shock absorbers. FERROFLUIDS open up a whole new world of DAMPING opportunities in that they may be used WITHOUT A CLOSED CONTAINMENT to capture them into position. Examples of this are in D'Arsonval meter movements, loudspeaker drivers, and digital stepping motors.

Design engineers go to great lengths to achieve proper lubrication of contacting machine elements that move relative to each other. To this end, they have invoked diverse design methodologies including oil sump systems with external circulation, internal splash mechanisms, and gel matrices that retain lubricating oil, i.e. greases. Ferrofluidic technology puts a powerful new tool in the hands of machine designers allowing them to EXTERNALLY COMMUNICATE WITH AND DIRECT LUBRICATING FERROFLUIDS TO CRITICAL MACHINE ELEMENTS whether in gear boxes, transmissions, universals, or bearings.

Levitation. The ability to create a force field on a magnetic fluid not experienced by other elements in a system allows seemingly an ANTIGRAVITY MACHINE.

This remarkable ability to levitate against gravity has been used by workers at the U. S. Bureau of Mines and other organizations to sort minerals and reclaim valuable industrial scrap by density difference of materials. For example, it has been stated that potentially some of the richest mines in the world are American automotive dumpyards which contain materials of ever increasing value and scarcity that were beneficiated at high initial energy cost. After shredding of automotive metal structures, it is straightforward to separate the steel from nonferrous metal nodules based on magnetic properties. The remaining metals, consisting of copper, aluminum, platinum, zinc, brass, tin and certain stainless steels, have high value only if they can be segregated into their respective species. The levitating property of magnetic fluid used to generate an apparent specific gravity in the ferrofluid medium intermediate between the densities of the metals in the "ore" has been successfully demonstrated and is currently being used in several instances including the separation of diamonds from rock.

Ferrofluidics Corporation has used the levitating principles of ferrofluids to create a stictionless proprietary inertia damper for the computer peripherals industry that speeds response time and increases accuracy in X-Y plotters and floppy disc drive head mechanisms. Under development are bearings and spindles that have potentially unlimited life, consume minimal energy, and have zero starting torque that will increase the reliability of machines while reducing escalating energy costs.

In the broad category of visualization, ferrofluids have been applied to novel displays, marking and sorting operations for automated quality control of industrial belting, semiconductor chip sorting, magnetic domain observation by scientists mapping the behavior of state-of-the-art magnetic materials, magnetic videotape quality assurance, and in high speed ink jet printers using magnetostatic deflection systems.

FERROFLUIDICS CORPORATION

It has been the mission of Ferrofluidics Corporation, over the last 12 years, to apply this exciting technology to important needs of different industries within American society and the free world community. Today, ferrofluids are the foundation of a proven technology that is vital to a number of key industries, to modern society, and part of maintaining U.S. technological leadership in the world community.

As the creator and technological leader of the ferrofluidic industry, Ferrofluidics has developed unique capabilities in ferrofluid synthesis, characterization, and applications. Our multidisciplinary technical staff, ultra modern facilities, precision manufacturing, and extensive product application testing, lead to products of consistently high quality and set new standards of industry reliability.

Ferrofluidics, designing with the latest generation of ferrofluids, offers reliable Ferrofluidic® components, assemblies, and systems. We provide practical solutions to problems either as a retrofit or as a new design.

Over the past decade, we have reviewed thousands of potential applications, determined those that were feasible and have successfully applied our resources to yield cost effective solutions ranging from one of a kind state-of-the-art prototypes to high volume production.

In the course of these efforts, Ferrofluidics' technology created unique new products by providing performance levels heretofore considered unreachable.

In the manufacture of semiconductor chips, the processing chamber must be perfectly sealed and vacuum tight since even the most minute exposure to atmospheric contamination can make the chip useless. Sealing requirements are complicated by the fact that the wafers must be rotated in order to achieve uniform properties. Thus the seal must reliably accommodate a rotating shaft into the vacuum chamber. Ferrofluidics' answer was a unique seal composed of ferrofluid and a magnetic circuit. The magnetic field confines the ferrofluid in the regions between the stationary elements and the rotary shaft of the seal. The result is a series of liquid barriers that totally prohibit passage of vapor, mist, gas, lubricants, dirt or other contaminants. The seal is virtually wearproof and has a lifetime measured in billions of shaft revolutions; it affords substantially reduced maintenance, minimizes "downtime" of production equipment, and significantly reduces the cost of expensive materials once lost through seal failures.

Ferrofluidic sealing components have become the accepted standard throughout the domestic semiconductor industry because of their proven leak-free performance and long-term reliability and are now seeing a rapid increase of international market share as well.

Ferrofluidics Corporation has vertically integrated its sealing technology from components up into subsystems such as the precision rotary lift subsystem used on a Czochralski silicon growing furnace. The elimination of atmospheric contamination, plus the precise mechanical fixturing of the rotary lift subsystem, has led to a rapid pay back for single crystal silicon producers resulting in increased productivity of their operations as well as improved competitive posturing of American firms.

Recently, Ferrofluidics Corporation has integrated even further into the systems business because of the substantial value added to these systems by Ferrofluidic sealing and mechanical technology. A new generation of Ferrofluidic Czochralski crystal growing furnace with many state-of-the-art features being introduced to the market at this very time is expected to establish increased levels of productivity and thereby reduce the cost of products based on semiconductor chips using silicon substrates. This same system will be used to produce monocrystalline silicon wafers to generate solar photovoltaic electricity for commercial and consumer use.

Ferrofluidics Corporation solved a vital problem in the computer peripherals industry with its totally hermetic, nonwearing sealing technology offering absolute exclusion of external, airborne contaminants as well as internally generated spindle lubricant vapors from the critical head/disc region. At the present time, virtually the entire industry in the free world economy that is engaged in the manufacture of high performance rigid disc drives are active users of this sealing technology or are phasing it into their production with currently over a million seals in service. In addition, Ferrofluidic inertia dampers are used on a variety of computer peripheral devices to enhance the performance of digital stepping motor driven systems such as head positioners on disc drive memories and computer graphic X-Y plotters.

Millions of audio drivers currently manufactured per year are protected from power overload, amplifier clipping, and thermal failure by using the improved heat transfer properties of ferrofluids magnetically positioned into the gap of the driver assembly. The principal benefits of this application are overall enhanced performance of speaker systems as well as reduced warranty costs for manufacturers. Ferrofluidic technology, in this application, also has the future potential of reducing the volume of premium critical resource permanent magnet materials or even allowing use of more available lower cost types of materials.

Ferrofluidics Corporation today is a rapidly growing transnational, publicly held company with operations in Europe and the Far East in addition to those in the United States. Employment figures change rapidly in this growing environment. At last count, Ferrofluidics Corporation directly and indirectly created jobs for approximately 300 American workers and contributed its share to the balance of trade by exporting over 30% of its products shipped to international markets in the last business period. Ferrofluidics is committed to remaining at the forefront of the emerging ferrofluidic industry and expends a substantial percentage of its revenue base on new product development to continue U.S. leadership of this important technological area.

THE NASA CONNECTION

The roots of ferrofluidic technology go back to Mr. Stephen Papell at NASA/Lewis, who was working on a proposed solution to the feeding of liquid rocket fuels from storage tank to engine in zero G environments. Subsequently, the work was picked up by my cofounder, Dr. Ronald Rosensweig, who was working at AVCO Corporation on a project related to SNAP-8 Nuclear Auxiliary Power for Extraterrestrial Vehicles. Dr. Rosensweig, working with Professor Resler of Cornell University, hypothesized a magnetocaloric energy conversion scheme which required a magnetic fluid and this led him into contact with Papell after reading of the NASA/Lewis work in a NASA technical bulletin. Rosensweig, with Papell's cooperation, duplicated Papell's achievement and succeeded in developing a rational scientific basis for the synthesis process allowing him to extend both the magnetic saturation levels of magnetic fluids as well as the range of fluid carrier systems. This effort was assisted by NASA/Langley and NASA Headquarters support over several years.

Ferrofluidics Corporation became fully active in January 1969, armed with a nonexclusive license from NASA to practice the Papell patents and an enthusiastic belief on the part of its founding group in the outstanding potential of the future of this technology.

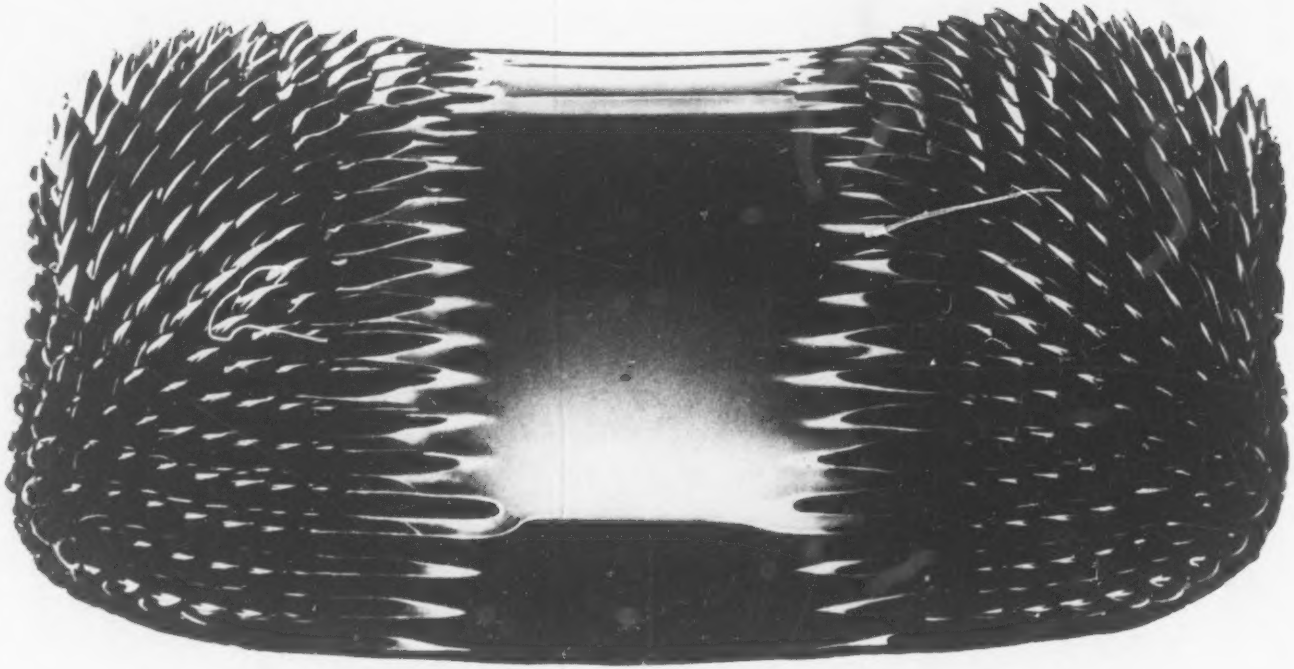
PROGNOSIS

There is a strong belief that the present applications of ferrofluidic technology, while exciting and growing rapidly in their commercial use, will be minor relative to applications of this technology in undeveloped areas. Ferrofluidics' technology is already being applied in limited ways in the energy field on flywheel energy storage systems and in deep-well logging devices for oil exploration. Reduction of toxic exhaust gases such as nitrous oxide have been reported using ferrofluid mist as a catalytic medium. A variety of separation processes using ferrofluids are under development leading to potentially lower cost extraction processes for minerals and efficient recovery of oil spills. Work in the medical community on ferrofluid applications range from the repair of brain arterial aneurysms to treatment of malignant cancerous tissues by selective absorption of radiation from a laser beam.

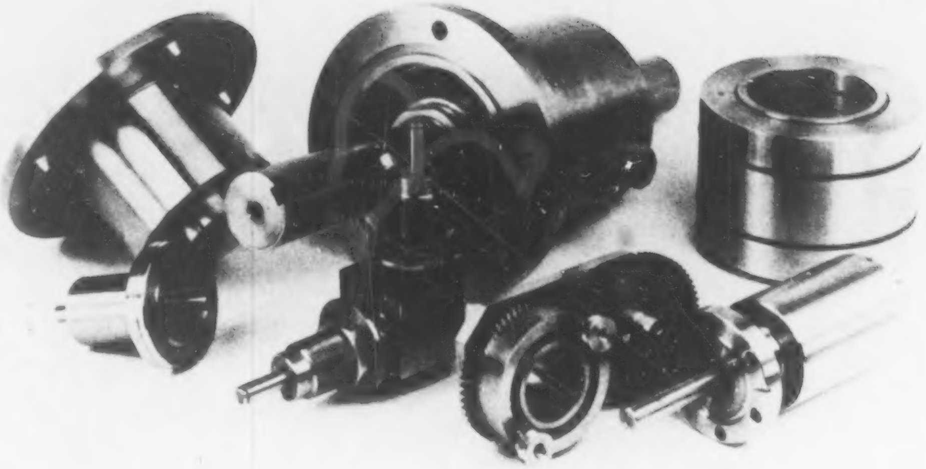
At Ferrofluidics Corporation, we believe that we are witnessing and participating not only in the successful creation of what we believe will be a major company but the emergence of a whole new industry with far-reaching benefits to many Americans and ultimately all of mankind.

Dr. Ronald Moskowitz
President
Ferrofluidics Corporation
40 Simon Street
Nashua, NH 03061

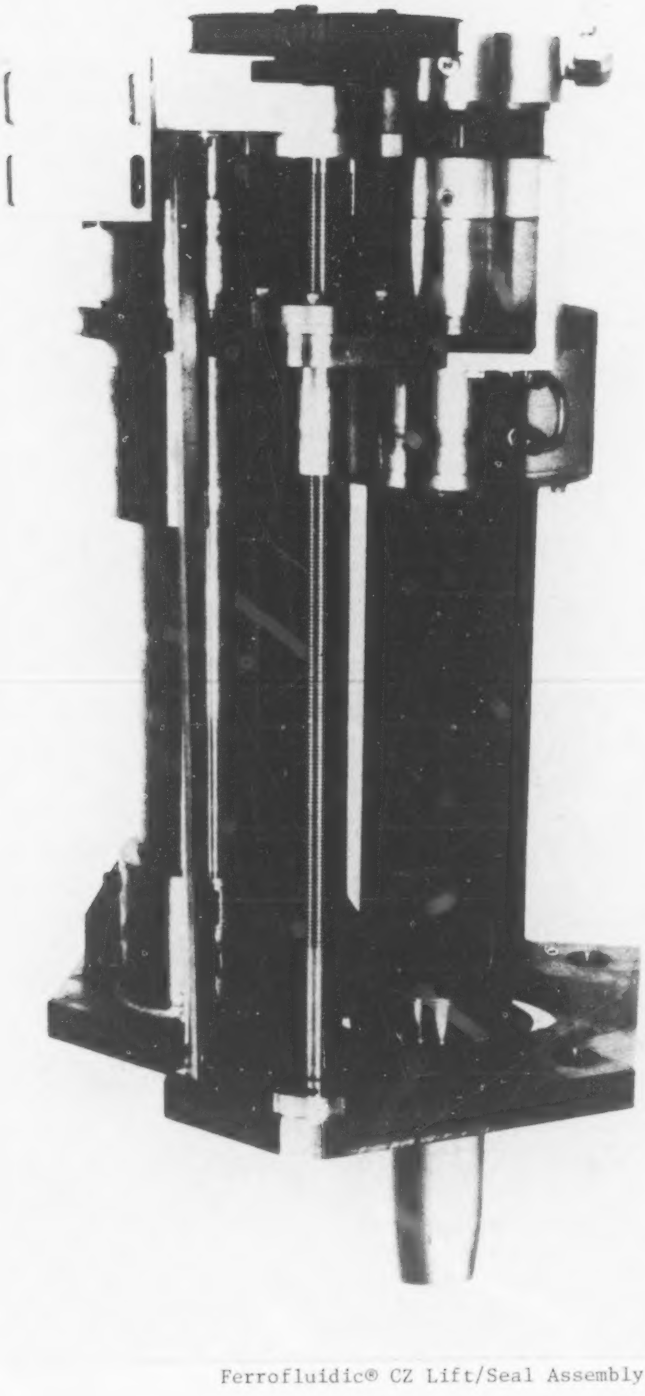
22 September 1981



Ferrofluids are a Unique New Class of Materials which can be Held in Precise Position by a Magnetic Field Gradient Defying the Force of Gravity.

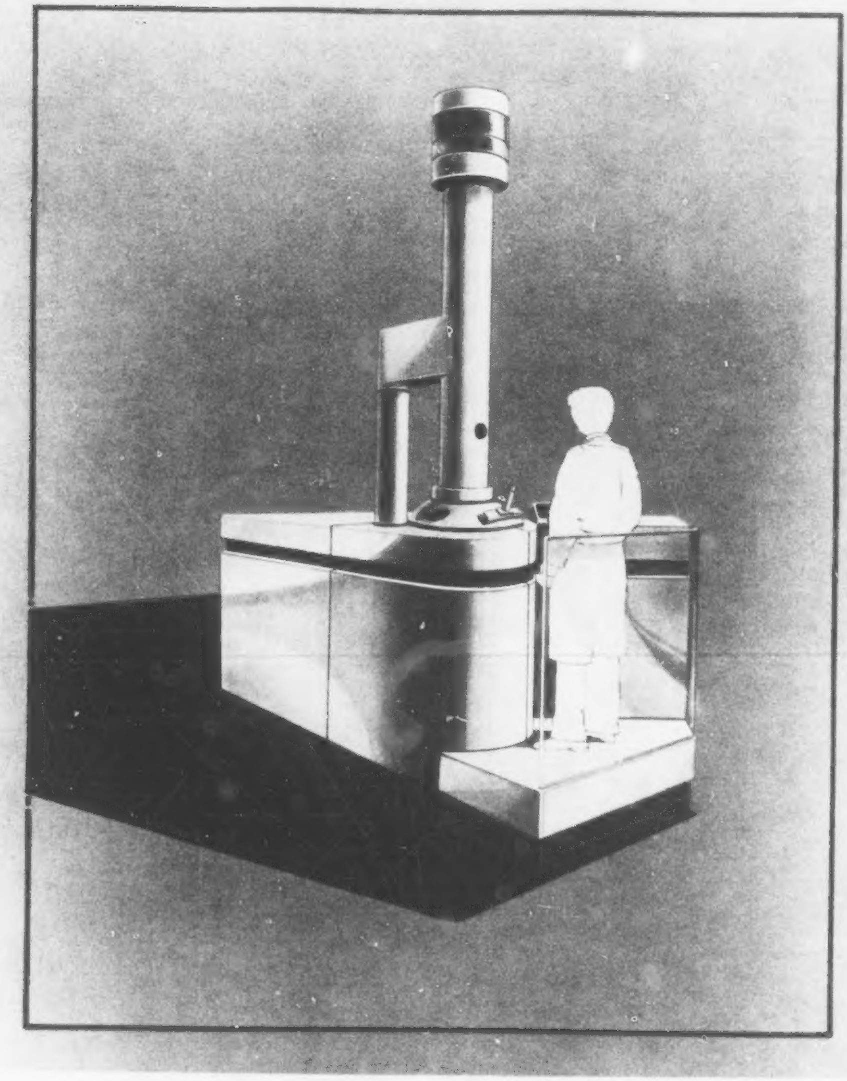


Ferrofluidic® Vacuum Rotary Seals Are Virtually Wear Proof and Substantially Reduce "Downtime" Caused by Seal Failure in Process Equipment Used in the Manufacturing of Semiconductors.

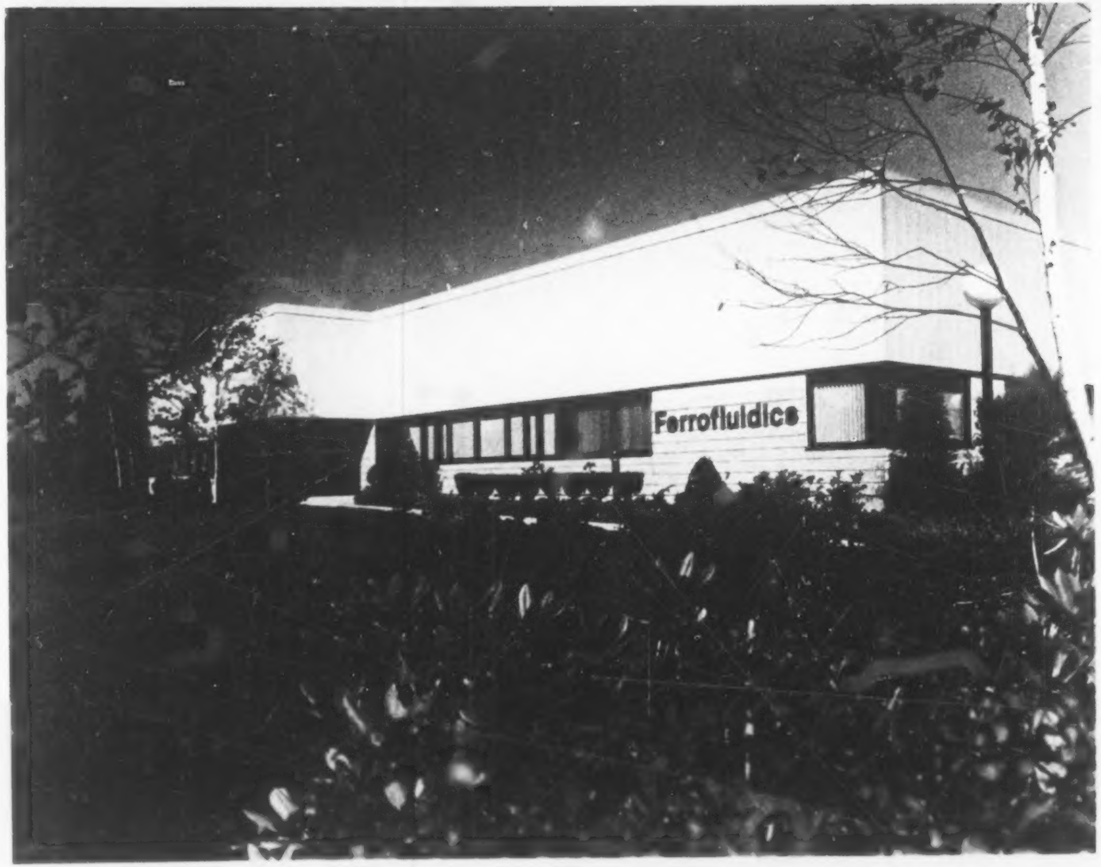


Ferrofluidic® CZ Lift/Seal Assembly for

Silicon Crystal Growing Furnaces.



Artist Rendering of the New Ferrofluidic®
Six-Four-Two Silicon Crystal Growing Furnace.


Ferrofluidics

The New Ferrofluidics Corporate Headquarters located in Nashua, New Hampshire

A Solution in Search of Problems

Magnetic fluids with unusual properties and far-reaching potential exemplify the scope and value of aerospace spinoff

Chances are you've never heard of ferrofluids: few people have. Yet ferrofluids—magnetic liquids whose unusual properties offer unique advantages in a wide range of applications—represent an emerging technology of such exciting promise it seems likely to spur development of a whole new industry.

Ferrofluids had their genesis in the early days of the U.S, space program. NASA faced a problem: how to feed fuel to the engine of an orbiting spacecraft when the fuel—like everything else in orbit—is weightless. A scientist at Lewis Research Center hit upon the idea of imparting magnetic properties to the fuel by dispersing within it finely ground iron oxide particles; the fuel could then be drawn into the engine by a magnetic source. Ultimately, NASA solved the problem by a different approach and ferrofluid research was shelved for the moment—but the Lewis investigations had planted the seed of a new technology.

Ferrofluids surfaced again in the mid-sixties. At Avco Space Systems Division, scientists were working on another space problem: how to control the temperature of a spacecraft which is very hot on the side facing the Sun and very cold on the other side. Applying their own expertise and drawing on the earlier NASA technology, they came up with a concept wherein a magnetic field would draw ferrofluid through a pipe-ring around the spacecraft, cooling the hot side and warming the cold surface. Once again an alternative solution was found and the operational debut of ferrofluids was delayed.

But not for long. Two of the Avco scientists—Dr. Ronald Moskowitz and Dr. Ronald Rosensweig—realized that ferrofluids offered vast problem-solving potential. Armed with a license for the NASA technology, which served as a departure point for their own further development of ferrofluids, they left Avco in 1969 and formed Ferrofluidics Corporation, Nashua, New Hampshire. Says company president Moskowitz: "We had no products and no customers. We were a company with a solution looking for a problem."

In their first year, they found a problem they could solve, one related to the manufacture of semiconductor "chips" for use in electronic systems. In semiconductor production, aluminum is deposited on silicon wafers within a vacuum chamber. The chamber must be perfectly sealed, since even the most minute exposure to air can destroy the aluminum's conductivity and make the chip useless. Sealing requirements are complicated by the fact that the silicon wafers must be rotated to get even distribution of the aluminum deposit. Thus, the seal must reliably accommodate a rotating shaft into the vacuum

Reprinted From: SPINOFF 1981
National Aeronautics and
Space Administration

Dr. Ronald Moskowitz, president of Ferrofluidics Corporation, displays some of his company's products. Ferrofluid—magnetic liquid—represents a new technology of exceptional promise in a great variety of practical applications.

chamber. This factor caused frequent chamber leakage induced by wear and breakdown of commonly used seals.

Ferrofluidics' answer was a magnetic seal composed of ferrofluid and a magnetic circuit. The magnetic field confines the ferrofluid in the regions between the stationary elements and the rotary shaft of the seal. The result is a series of liquid barriers that totally bar passage of vapor, mist, gas, lubricants, dirt or other contaminants. The seal is virtually wear-proof and has a lifetime measured in billions of shaft revolutions; it affords substantially reduced maintenance, minimizes "downtime" of production equipment, and significantly reduces the cost of expensive materials once lost through seal failures.

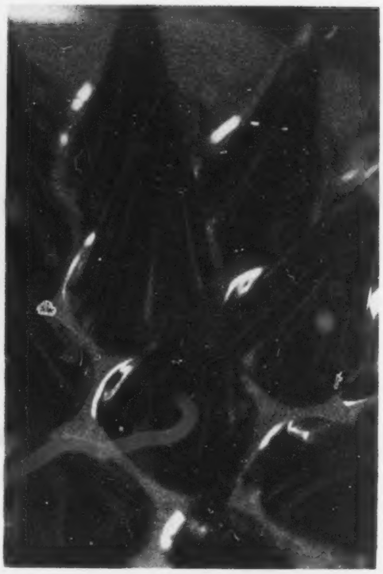
From that start, Ferrofluidics expanded rapidly into many other applications. Among products based on ferrofluid are exclusion seals for computer disc drives and inertia dampers for stepper motors. Ferrofluids are also used as performance-improving, failure-reducing coolants for hi-fi loudspeakers. They are finding growing acceptance in a variety of industrial processes, analytical instrumentation, medical equipment, silicon crystal growing furnaces, plasma processes, fusion research, visual displays and automated machine tools. And that's only the beginning. Dr. Moskowitz sees an "awesome" range of potential applications, from artificial heart pumps to cleaning up oil spills.

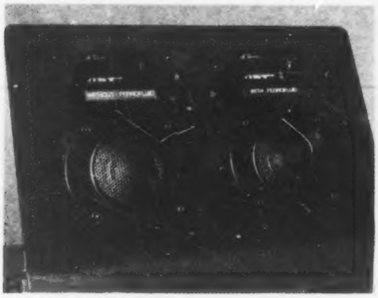
From a sales volume of $65,000 in its first year, Ferrofluidics has expanded to annual sales in the multimillions and expects to top the $100 million level within the decade. Now a multidivisional company with European and Japanese subsidiaries, it rapidly outgrew its first plant and is already considering expansion of its new, considerably larger facility. Ferrofluidics is the sole production source for ferrofluids and ferrofluid systems, but there is growing interest in the broad potential of magnetic fluid technology. Says Ronald Moskowitz: "What the NASA technology launched was not just a single company but probably a whole new industry."

The Ferrofluidics story is an outstanding example of the aerospace spinoff process. It shows the universality of spinoff—how a technology originated to meet aerospace needs can be reapplied in many ways remote from the original application. It also underlines the economic potential of spinoff; as happens frequently, this technology transfer resulted in establishment of an entirely new company, with attendant benefit to the nation's Gross National Product and job creation. Spinoffs whose benefits are valued in the millions of dollars are not unusual. In other cases, spinoffs generate only moderate economic gain, but provide significant public benefits in other ways, ranging from simple conveniences to important developments in medical and industrial technology.

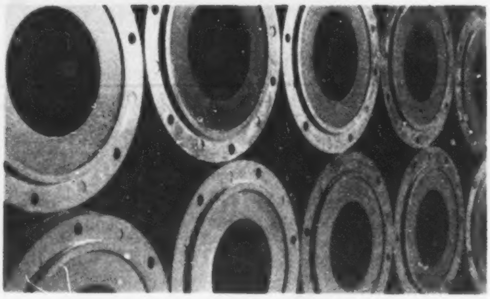
For almost two decades, under its Technology Utilization Program, NASA has been actively engaged in promoting the secondary application of aerospace technology. During that time, thousands of innovations originating in aerospace research have found their way into everyday use. Collectively, these spinoffs represent a substantial return on the aerospace investment in terms of economic gain, improved industrial efficiency and productivity, lifestyle innovations, and solutions to problems of public concern.

Above, ferrofluid is being pulled in two directions by two magnetic fields. It illustrates how the fluid—which contains freely-suspended submicroscopic iron oxide particles—can be positioned and controlled by a magnetic source. This capability offers many unusual useful applications. The "spiking" phenomenon shown in close-up at right is caused by the energy balance between magnetic forces and surface tension.

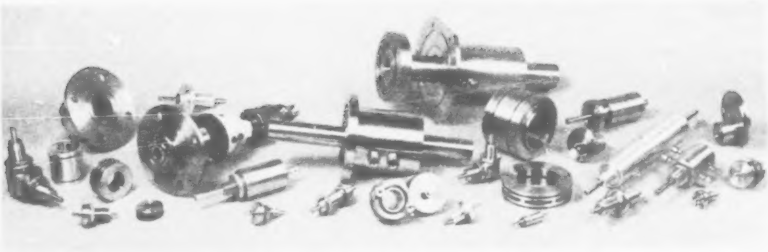




This photo illustrates the efficiency of ferrofluid used as a coolant in hi-fi loudspeakers. At left is a conventional speaker. Ferrofluid was injected into the voice coil segment of the speaker at right. The digital readouts show the relative temperatures: 228 degrees Fahrenheit for the conventional unit, only 85 for the speaker containing ferrofluid. Effective cooling of the voice coil substantially increases the loudspeaker system's ability to handle higher power levels and decreases the chance of speaker failure.



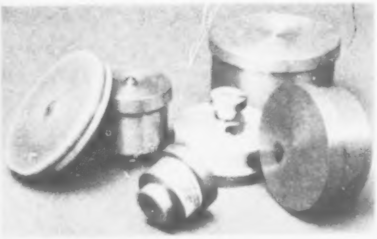
A major Ferrofluidics product is an exclusion seal for computer disc drives, which are highly susceptible to contamination; a tiny mote of dust, one-tenth the diameter of a human hair, can damage the disc head and cause loss of the data in the disc's memory. More than a score of computer equipment manufacturers are using Ferrofluidics' seals, which have proved highly effective in protecting stored information.



Among products manufactured by Ferrofluidics Corporation are rotary seals, in which a magnetic circuit controls ferrofluid to form wear-proof liquid barriers that totally block passage of contaminants into sealed vacuum chambers. The company now offers a large line of seals, produced by its Vacuum Technology Division. Ferrofluidics also has Computer Products and Audio Products Divisions.

Ferrofluidic® is a registered trademark of Ferrofluidics Corporation

Ferrofluidics recently extended magnetic fluid technology into a new area with the addition to its product line of a system for improving the operation of silicon crystal growing furnaces. Single crystal silicon is the key starting material for solar cells and semiconductor chips. The company's crucible lift system shown lifts and rotates a crucible of molten silicon during the crystal growing process. The highly precise mechanical device permits higher productivity and purer silicon by reducing vibration and contamination.



Ferrofluid offers an effective medium for damping—reducing unwanted vibration—in "stepper" motors, used in such systems as plotters, computer printers, motion picture duplicators, and machine tools. In the photo above is the company's family of Ferrofluidic Inertia Dampers.

The brave new world of fluid technology

by John Siack

A fluid that is magnetic?

My high school physics teacher would have loved it, if he could have dreamed such a thing were possible. After all, any dolt knows that solids are the only materials that possess strong magnetic properties. And that's what this dolt thought until he ran into the Ferrofluidics Corporation in Burlington, Mass.

As Dr. Ronald Moskowitz, Ferrofluidics' president, points out, this is the first time in the history of mankind that a force other than gravity or centrifugal force can be exerted on a fluid. He says magnetic fluids have placed a new technology at society's disposal, with broad and far-reaching implications.

As you talk with Dr. Moskowitz, he opens your eyes to his world of ferrofluids and you begin to share his enthusiasm. The realization hits home that this isn't just a new company you've discovered, this is a brand new industry, and Ferrofluidics is the only company in it thus far.

The roots of magnetic fluids can be traced back to the early days of the space program. There is no "down" in space and everything tends to float around, so scientists wanted to discover a way to feed fuel to an engine in a zero-gravity environment. Moskowitz says they hit upon the idea of creating a magnetic gravity that would allow the fuel to be fed automatically.

Before the idea got very far, solid propellants came along and solved the problem, but enough work had been done to show that it was feasible to even think about magnetic fluids.

Magnetic fluids remained in limbo for a few years. Then the idea cropped up again at Avco, the aerospace company, as a possible solution for another problem found in space. A non-rotating vehicle in space becomes very hot on the side which faces the sun, and is very cold on the side that looks into space. This presented scientists with the problem of providing space vehicles with thermal equilibrium. Moskowitz says a magneto-caloric concept was developed in which a ring or a pipe of fluid with a magnet, could circulate the fluid around the vehicle. The circulating fluid would cool the hot side and heat the cold surface.

It was a great idea, but the development of magnetic fluids was to be delayed once again. This time it was money.

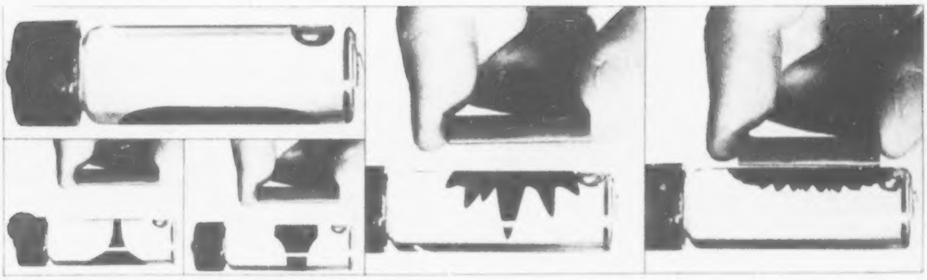
In the mid-1960s the well went dry. The war in Vietnam turned off the flow of government funds for research and development, and projects like magnetic fluids were once again in limbo.

But not for long. The scientists who had been involved with the development of the fluids could see that they had something potentially big on their hands. They had a very powerful new tool that could solve a number of industry's problems. The trick was to go out and identify the problems.

Ferrofluidics was born on January 1, 1969. As Moskowitz puts it, "We were a company with a solution looking for a problem." There were no known applications for the product when the company started 10 years ago, and none of the fluids the company sells today existed then. Indeed, sales for the first six months reached a grand total of $75 from a researcher buying a small amount of ferrofluid.

By the end of the first fiscal year, the company had identified its first product, and sales totalled $65,000. The first market was the hard vacuum processes used in the semiconductor industry. The non-wearing and zero-leakage properties

Magnetic ferrofluid is used in sealing, will bond for billions of revolutions



(Reprinted from *New England Business*)

of ferrofluidic sealing were the answer to the industry's need for seals that would not only keep out contamination, but also would not break down and become a source of contamination.

The unique qualities of magnetic fluids make them ideal for sealing high-speed shafts in vacuum systems. The fluids are magnetized by dispersing very fine magnetic particles into them. The particles are coated with a substance that prevents them from sticking together, and, because they are so small, thermal molecular agitation in the fluid also keeps them from settling or joining together.

When the fluid is positioned by a magnet, it forms a seal that fills the gap between the shaft and the outer housing. Tests have shown that if there is any leakage it's immeasurable, and the life of the seal ranges to billions of revolutions.

The vacuum market gave the company its start, and the next few years were spent developing the vacuum market for Ferro-metic seals, evaluating other potential markets for ferrofludic sealing, and investigating many other possible applications of the technology. Those applications range from artificial heart pumps and cleaning up oil spills to treating cancer and converting thermal energy directly into mechanical energy.

Sales are now running at a $3-million rate and are doubling every 12 months. If that pace keeps up, the company will hit their target long before its second decade arrives.

Rather than spread its resources too thin, the company set its sights on three markets — semiconductor processes, computer peripherals, and, surprisingly, audio high-fidelity speakers.

It is a long way from vacuum seals to hi-fi speakers, but ferrofluids made the jump easily. In 1973, the company began selling the fluid to loudspeaker manufacturers who add a small amount of it to the moving coils of the speakers. The result is loudspeaker systems that have moved one step closer to perfection.

The fluid aids in the manufacturing process by providing a simple and automatic means of centering voice coils, and it assists damping of the moving system while it improves the thermal energy dissipation capability of the voice coil. The fluid provides a 600-percent more efficient heat path to the main structure of the speaker — reducing burn-outs and warranty repairs. And performance has been improved so much that manufacturers can now design speakers of almost half the size and get the same performance.

As might be expected, the most rapidly growing market for the company is in computers.

A computer disc drive turns at high speed and the read/write heads float on a cushion of air which is often less then 000100 inches above the disc. To put this in perspective, a smoke particle at 000250 inches is larger than the gap between the disc and the heads. A human hair is gigantic by comparison.

All of this means there is an urgent need to keep contaminants out of the disc drive assembly. The heads can crash into even a speck of dust and the collision will be costly because it would not only damage the head, it can destroy the data on the disc.

The problem exists not only in hostile field environments like factories. Even in sterile climate-controlled computer rooms, the drive can produce the contaminants that will cause it to self-destruct. Lubricant particles from its own drive system can cause a crash, or dust particles can materialize from the very seals that were installed to keep contaminants out.

Ferrofluidics has the answer to the problem, and the company expects that the unique rotary seals it sells for use on disc drive memories will account for 50 percent of its revenues over the next five years. Control Data is now a major customer for the seals, big names like Sperry are in production, and most of the remaining industry giants like Hewlett-Packard and IBM are actively testing the seal. Moskowitz says significant new orders are expected in the future.

Needless to say, the future of the company looks bright and everyone there knows it. The air at Ferrofluidics literally crackles with their enthusiasm. As Moskowitz puts it, "We are a $100-million corporation, temporarily at $3-million." And he isn't kidding.

The market potential the company has identified indicates sales could exceed $100-million in the next 10 years, but Moskowitz says he'd prefer to get there in six. Sales are now running at a $3-million rate and are doubling every 12 months. If that pace keeps up, the company will hit their target long before their second decade becomes history.

Past growth and future needs have resulted in the company outgrowing the present facility in Burlington. A new facility will be built in New Hampshire and the company hopes to move in by next fall — another example of Massachusetts' loss being the Granite State's gain.

For investors, sorry to say, the company hasn't gone public yet. It will be a while before they get a piece of the action. Moskowitz says the company will offer stock to the public someday, but he wants to do it right. He says sales should be running in the $10-million to $30-million range before the company would even consider going public.

But remember the name. You may never see any of the company's products on a supermarket shelf, but the work they are doing is bound to affect your life in one way or another someday. ■

John Slack is a vice-president of Moseley, Hallgarten, Estabrook & Weeden Inc.

Mr. FLIPPO. Thank you all very much, gentlemen. The testimony has been outstanding.

Considering the success in the ferrofluids technology, did you say that you didn't think it would develop—why did it develop at the time it developed? Why did it blossom at this time?

Dr. MOSKOWITZ. Your question is why has it taken this long?

Mr. FLIPPO. I am trying to ask whether or not it would be here without the space program. Would it have developed anyway?

Dr. MOSKOWITZ. That is always possible. I can't really say that for sure. I am sure that magnetic fluids—you know, human resourcefulness is such that given enough time, we will solve our problems.

I think magnetic fluids fell out of the space program. There was a technical information bulletin or brief available that my cofounder Dr. Ronald Rosensweig was made aware of at a time when he needed such a material and that provided encouragement.

He was in contact with Mr. Steve Pappell at NASA/Lewis who cooperated heavily. The bottom line of it all is it happened because there was a space program and I can't honestly say that I believe that it would have happened anyway if there wasn't, but maybe not in your and my lifetimes and maybe not in our children's lifetimes.

Mr. FLIPPO. Probably not as quickly as it did.

Dr. Long, would you say that might be true in the areas you have discussed, too?

If we had given the money directly to the medical community for R. & D., would they have been developed sooner, or without the space program, would we still perhaps not have those devices?

Dr. LONG. I think the technology available from the physical scientists of the space program is indispensable. Physicians are simply not trained to do these kinds of things. We might have the concept of what we wanted to accomplish, but there is no possibility that any physician I know could have carried out this kind of engineering.

Mr. FLIPPO. You know part of the problems we have to deal with is that people say, well, you can put that off, that R. & D., that effort that you are making in the space program, because of these other pressing problems.

You can delay your efforts in the space program. I think these are outstanding examples of what happens if you don't.

Dr. Long, can you think of any other efforts aimed at the health, rather than illness? I guess what I am trying to say is the prevention of illness.

Any kinds of technology, space technology? Has NASA contributed in that area, in areas with which you are familiar?

Dr. LONG. That is not an area where I am very familiar because the nature of neurological disease is that the brain either works or it doesn't.

I really don't know of any high technology that is being used in the health maintenance aspect of medicine.

Mr. FLIPPO. In all the testimony, I believe you are saying that the transfer of this technology was accidental, almost. Not totally, but at least an unusual set of circumstances had to come together for the technology to transfer.

Dr. Long, I believe you said that we needed to plan the transfer and Dr. Moskowitz, I believe you said you didn't think we could plan the transfer.

Help me a little. I don't think you really have opposing points of view, but help me understand how we can encourage this transfer among disciplines.

Dr. LONG. Well, I think what I mean by planning is not so much that you can foresee every consequence and have a channel going from—A to point B that has no possible variation, but rather, that you should not simply wait for all this to happen and hope something comes out at the end.

If everybody involved, if all the physicists and engineers know from the first day what a number of the potential medical problems are and if all of the physicians involved in solving these problems know the directions of the planning program and what kinds of areas are going to be studied, then there is a much greater chance that at various steps along the way, they will see ways for these things to become practical medical devices.

The ferrofluids are a very good example. I happened to hear about these by accident a long time ago, probably 7 or 8 years ago, through Dr. Roth's work.

I happen to have a completely different experimental use for them and used them on determining why some substances go into the brain and some don't. That was purely an accident.

However, had I been able to sit and listen to NASA scientists present materials that have absolutely nothing with my field, many more such accidents are likely to occur.

I don't think we ought to wait for them to happen. I think we can really augment the process by making sure that the two groups of people are together and knowledgeable about what the other is doing.

Mr. FLIPPO. Dr. Moskowitz?

Dr. MOSKOWITZ. Certainly you can plan for major engineering undertakings such as putting a man on the Moon or putting up a communication satellite system or something of that scale.

However, one might ask the question, why is it that in period of intense work such as the NASA work toward putting a man on the Moon or during World War II, there was such tremendous technology developed? I suspect that one reason is that there is a great intensity and direction, but there is also a mixing of interdisciplinary skills.

People who don't usually talk to each other start talking to each other and it is this whole business of communication, I think, that Dr. Long just referred to that is probably the most central issue.

We need to be aware of what NASA is doing in order to make use of it. Don't forget, it was a NASA innovation and also it is the communication thereof to Dr. Rosensweig, my co-founder, who provided that particular continuity.

I think NASA has done a good job with their technical briefs and things along that line.

It is the mixing together of interdisciplinary skills which don't normally get mixed. I taught at several universities prior to starting this company. I will tell you that people in the department next door don't even talk to each other.

Usually you know what is going on in other universities in your field, but you don't know what is going on in the guy's office next door. You may not even know the guy!

Mr. **Flippo**. Dr. Long, we do have a vote on the floor and we are going to have to go vote, but I would like to know, from the area of your efforts now, how broad are these benefits?

How many people are likely to be helped in the area that you specialize in and what about cost?

Dr. **Long**. Even though neurosurgery is a small field, these are things that have broad application. Head injury is one of our major important public health problems. There are several hundred thousand serious head injuries each year in the United States and probably 60 percent of them need this kind of monitoring.

Pain is a very major problem. Not nearly all patients need this kind of really major effort to try to control it, but even so, the people who do—and there are many thousands of them in the world—are very expensive patients.

Our average patient would come to one of these devices, he has spent $100,000 in medical costs and has undergone six operations.

Of course, the drug pump has applications throughout medicine and should be something of very broad potential. They are expensive technology, but they are worth it, both for the individual patient and, I think, for the reductions they will make in other medical expenses.

Mr. **Flippo**. Gentlemen, the current recommendation of current administration was for the elimination of the technology utilization and technology transfer funding for NASA.

This committee rejected that approach and has made a long history in its efforts to have technology utilization and technology transfer.

I think the committee is going to continue to support those even more strongly than ever before, but I wonder if they are, leaving budget considerations aside, are there institutional changes that you think should be made to enhance the technology utilization process?

Any of you who would like to respond to that, please do.

Mr. **Pascente**. I recommend the formation of a new body which would consist of both Government and industry which will look at all these new technologies that will come out of either NASA or any other Government problem to then be transferred to industry or to wherever it may be and let this organization look at the technology in terms of all the planned benefits that go with it and really look at the cost-benefit ratio associated with the technology and really verify this technology as really needed, as opposed to the system that exists, today.

Dr. **Long**. I think there are two very important things. The first is the interaction between NASA physical scientists and the medical community.

The second is exactly the same. This is an improved way to take the prototype device after it has been studied well and move it to the marketplace where it benefits a large number of people.

I think that is where we have our greatest problem now.

Dr. **Moskowitz**. We talked about communications as being a vital area. I think a second word I would like to introduce here is cooperation.

I think our Japanese friends have shown us some of the power of cooperation when they have industry, government, and universities cooperating together, and what they can accomplish in various industries.

I would like to see a lot more of that done in this country. I would like to see, instead of industry and Government being adversaries, I would like to see them playing on the same team insofar as it is in the public good.

I think the current tax legislation that has recently been passed, including the tax credit for R. & D., have been a good step in the right direction.

I would like to propose a step further along those lines, giving companies, say, under $10 million in sales, an even larger credit on a matching-grant basis as to where a company can contribute to a university and receive a matching grant for a comparable credit.

That will direct our universities into areas of much more practical utility, it will enforce cooperation between industry and academe Government will be doing what it should be doing, keeping its nose out of the implementing and providing the overall guidance and structure of the program.

I know that I didn't quite exactly answer your question precisely, but this has been a particular thought of mine for some time.

Dr. **Long**. Mr. Chairman, I certainly like his answer.

Mr. **Flippo**. I think the committee would probably agree with you for most of the tax cut.

Mr. Brown, any questions?

Gentlemen, thank you very much. We are going to have to go to the Chamber and vote. Your testimony means an awful lot to us.

Thank you for being here with us today. We will stand in recess until tomorrow morning at 9:30 in room 2325.

We expect to have with us more excellent witnesses.

[Whereupon, at 3 p.m., the subcommittee was adjourned, to reconvene at 9:30 a.m., Wednesday, September 23, 1981.]

FUTURE SPACE PROGRAMS: 1981

WEDNESDAY, SEPTEMBER 23, 1981

House of Representatives,
Committee on Science and Technology,
Subcommittee on Space Science and Applications,
Washington, D.C.

The subcommittee met, pursuant to adjournment, at 9:40 a.m. in room 2325, Rayburn House Office Building, Hon. Ronnie G. Flippo (chairman of the subcommittee) presiding.

Mr. Flippo. The meeting will come to order.

This morning we conclude this round of hearings on future space programs with a panel of very distinguished witnesses. Before we begin, I just want to say a few words about the previous days' hearings.

We have heard from a historian, a demographer, a futurist, a medical doctor, a space entrepreneur, a promoter of popular support, and engineer-businessmen who have taken space technology and applied it elsewhere. We have had much interesting testimony which will be very helpful to us as we try to devise a space program for the future.

At the time of our 1975 hearings on the same subject, Dr. Edward David, a former presidential science adviser, said:

> * * * These matters go in cycles. There are times when society places great value on exploration and adventure. We are not now in that phase. It is a time of consolidation and self-examination. However, it is during just such times as these that we must be preparing for the future.

In the 6 years that have passed, we seem to have made mixed progress. We have prepared for the future by building the shuttle, but we don't seem to have completed the "self-examination" Dr. David referred to.

George Will wrote recently—with eloquent sadness—about the lack of administration support for a mission to Haley's comet. He said, "If our curiosity about such things atrophies, so will our humanity." He concluded with a statement that applies broadly to the space program and much of science--

> We know next to nothing about virtually everything. It is not necessary to know the origin of the universe; it is necessary to want to know. Civilization depends not on any particular knowledge, but on the disposition to crave knowledge.

The space program is a part of what it means to be human and to have a future. And just as we don't talk about cost/benefit ratios when we think about having children, so we shouldn't limit discussions of space programs to those that have a favorable ratio. The reason is similar for both—they are our future.

So in these hearings—the past few days and this morning—we are trying to move through the period of self-examination and into a period of exploration and growth. Our witnesses today represent a broad spectrum of experiences and they should be able to help us greatly as we try to decide where we are going in the future.

Our first witness today is Dr. W.O. Baker.

Dr. Baker, if you would please come to the witness table. We could spend several hours introducing Dr. Baker, because he is a man of great experience and has made great contributions. Just let me mention two things. First of all, he led Bell Telephone Laboratories as president and then chairman of the board over the years when it became and remained perhaps the premier physical science research laboratory in the world. Obviously this man has something to tell us.

Second, let me bring us up to date by saying that he has been named to receive the Vannevar Bush Award by the National Science Board.

Dr. Baker, we are indeed pleased to have you. Please feel free to proceed as you deem appropriate.

Mr. Brown, would you have any comments you would care to make?

Mr. BROWN. They would be superfluous. I have had the privilege of working with Dr. Baker over the years, and I can vouch for the very important contribution that he makes to the work of this committee. We are very pleased to have him here this morning.

STATEMENT OF DR. W. O. BAKER, FORMER PRESIDENT, BELL LABORATORIES

Dr. BAKER. Thank you, Mr. Chairman and Mr. Brown, for your gracious welcome, and good morning to the members of the hearing. We will seek to economize on your time and schedule by summarizing our response to your thoughtful theme. We are always stirred by the meetings of this committee and its subcommittees, which have played such a vital part in the progress of science and engineering, and in the role of our Government in this Nation. We look forward to any occasion in which we can respond to your interests in major research and development activities.

The space program has already been such a great triumph in so many ways, as we point out in our notes to you, that we shall not attempt, in projecting into the future, to think of those qualities alone being extended. Your other very distinguished witnesses and experts, particularly those who will appear today, will deal with that vital matter. Rather, we shall seek to reflect on how industrial and economic activity can serve the public, national, purpose in collaboration with the national space program in the far future, that is, in the decades that you have cited, 20 to 50 years hence.

For us, we are assured that there is going to be a vital part in this future for both industry and the Government in this field, because of a modest program of independent experiments we have undertaken in our laboratories in the last decade. These have to do with the geosphere—which perhaps in tune with the spirit of the times seems like a rather modest retraction of exploration in the cosmos. It is by no means abandonment of the achievements and interests in far space, but rather a realization that near space holds promise and importance not fully recognized or pursued.

The geospace includes especially, the magnetosphere and the qualities of the environs of the Earth which are occupied, by the waves and particles that may come from outer space, and especially, of course, from the Sun.

Mr. Chairman, we are finding that the behavior of the geospace—as has been speculated on for generations by astronomers and astrophysicists and even astrologers—we are finding that the range of physical and engineering phenomena there exceeded expectations and provides very exciting frontiers to be followed up.

Now let me add quickly that these frontiers, which we will just touch on exceedingly briefly in a couple of minutes, can be followed only by what we believe is a special cooperation of Government and industry, underlaid by and supported by, of course, the absolutely essential role of education and research in universities and research institutes. So what we are reporting to you about the space programs in a pragmatic sense for the next era does require a novel and ingenious combination of resources of government, industry and the academic realm.

The issues that we are describing in this geosphere, in geospace, are matters of academic insight, above all. That is where the first understanding and in the future the prime investigation will occur. It is not like a Jules Verne situation, where everyone in a civilization has been captivated by voyages to the stars. And those goals, of course, are the enormous inspiration in which we operate. Rather, this is a situation of the most detailed examination of the environ of the Earth in the most scientific and analytical way, so the universities must play a very important part.

I know, for instance, of Mr. Winn's deep interest in how the National Science Foundation and other agencies can augment academic capabilities, and here is a place where that can be invoked.

The qualities of this geospace are exciting, especially because it is full of plasma this is a charged matter state containing atoms and molecules and particles with which we deal in many, many ways, and which are fundamentally the essence of science and technology on earth. In plasmas, those entities simply exist in curious dilute, nervous kind of equilibrium, going go all the way from electrons and protons and gamma rays and cosmic rays to charged molecules of carbon and oxygen, hydrogen and nitrogen.

The energies involved in this surrounding of the Earth are very large. Indeed, as we have remarked in the notes, they correspond in the cutting of the fields which are out there to about 10^{12} watts, about the electric energy consumption of the United States. That is just an incidental byproduct of the motions and interactions of this plasma that we are referring to.

The plasma containing these charged particles is, of course, also the basic ingredient of fusion energy generators, and of a great host of industrial and economic processes on Earth. Among these are the preparation of integrated circuits which we and others have had the privilege of reporting to this committee before about, as one of the leading edges of American economy and technology. It is, therefore, intriguing that nowadays those circuits are prepared by the interaction of certain films with a plasma, a chemical plasma.

We are as uncertain of the detailed properties of that plasma, what its potentials are on Earth, as we are of the broad significance and qualities of the plasma around the Earth, which can be probed really effectively only by space vehicles and by space instrumentation. Incidentally, that space instrumentation itself, as pursued in our laboratory and others, has produced valuable consequences.

The study of the particles in the Van Allen Belts and in the whole range of the profile of the geosphere has required very precise measuring circuits. In these, we make analog measurements of the charges and their energy, their position, and these have to be converted to digital circuits, to digital signals, for the best transmission and processing. Some of the most sophisticated analog to digital converters ever made, which you perhaps would associate, quite properly, with a vital part of the modern Information Age and of the communications and computer activities of our times, were stimulated by the need for instrumentation in the satellites which have probed the geosphere.

Finally, one should emphasize that this plasma around the Earth that we are talking about, and whose exploration, measurement and application we are saying should be the primary focus for the space program of the decades to come, that is animated by solar wind. This is, of course, the propagation of particles from the sun, partly by explosions on the surface of the sun. These sunspots and other effects have long been known as determinants of weather, determinants of great cycles of climate on Earth. We are trying to understand them.

I am submitting to you, sir, the finding that we shall understand these only, and even then incompletely, but only after much more exacting and precise studies of the geospace by satellite and space technology. This science has to be supported by launch systems, and by vehicles which are beyond the capability of any single independent institution at present. Therefore they are indeed suitable for your careful consideration as a matter of national policy.

Sir, I have summarized very hastily and I am sure incompletely, what seem to us to be the vital and demanding features of the pragmatic promise of space science and technology in the decades ahead. I would be be happy to respond to any questions.

[The prepared statement of Dr. Baker follows:]

Planning Today for Future Space Program; Pragmatic Views of Implications for Industrial Science and Technology and Thus for Economic and Social Productivity and Progress

W. O. Baker

The programs and achievements of the United States space activities since the mid-Century have been heavily guided by issues of national security, prestige, public excitement and a modest but important component of scientific and technical exploration and discovery. We gather, however, that presently this Committee wishes to examine other aspects of extraterrestrial exercises. Such may particularly include those extending from our original experiments in communications with Echo and Telstar satellites, from which have now grown a socially and economically important world satellite communications capability.

Similarly, it appears that global imaging and surveillance, begun and continued as a vital element of national security, are now showing good potential for social and economic use, as in crop and weather estimates, mineral and survey improvements, etc., reflected in the LANDSAT and weather observing systems. We support these themes, which were brought out expertly in the report of the *Subcommittee on Space Sicence and Applications*, on April, 1981, referring particularly to hearings of July, 1980, on the United States Civilian Space Policy. In order to emphasize our understanding that a new perspective is now being sought, we note activity of our Laboratories in the public excitement -- national prestige theme as the BellCOMM systems engineers for the Apollo project. As well, we developed the electronic guidance techniques and computer programs for space missiles and propulsion methods in the Nike anti-aircraft systems and the Safeguard ABM system. This work has given us a kindred understanding that now is time to look at new possibilities of space studies and potentials. We are aided in this by the cumulative knowledge and experience of more than two decades with the programs you have reviewed a year ago, and indeed by even a little longer time with our own industrial scientific and technical commitment to the basic control and sensing resources on which all our present space technology and engineering are based.

Concerning these resources, it is well to note, as we shall develop more fully in a few minutes, the breadth of knowledge that they encompass. Thus, in our own case the Bell solar battery from solid state physics and materials science was discovered independently of any space program, but has been the uniform source of power and of utility of virtually every space object ever launched, including that by other nations such as the Soviet Union. Similarly, the transistor and its host of solid state science descendants have played the role Sir John Cockcroft noted in a British association talk generations ago, that the space program would have been inconceivable without this frontier of science and technology, which came out entirely independently of it or any related stimulus. Also, similarly, materials science and engineering was far along in its modern forms before the space actions demanded its best efforts. And the marvelous propulsion and combustion processes that had to go into these rocket materials, housings and engines have also come from the fundamental chemistry of energy conversion and the development of localized rockets years ahead of 1958.

Now I guess the point is obvious, that on one hand any vast technology such as space technology demands a knowledge base founded long before the applications came out. But on the other hand, the use of new knowledge such as from space exploration may in turn form a very broad new base, or at least contribute to a very wide ranging extension of knowledge. It should not be contained in some particular field such as weather forecasting, land surveillance, zero gravity fabrication or whatever.

Accordingly, the industrial positions on which you are inviting our comments, and which certainly need to be considered for the long term, will vary from the attractive and compelling themes that you covered a year ago. But these latter themes are the principal issues in space activities recognized popularly, and in governmental and public objectives. To repeat, the different concepts we now forward will generally have much broader basis of science, with a pervasive slant toward engineering science, than the big projects. They will be more intimately connected with earthbound phenomena, reflecting the social and economic parameters in industry. They will, in general, be capable of rather rapid and uncostly revision, unlike the heroic experiments of achieving a moon landing.

Not surprisingly, these doctrines from industrial R&D suggest that we emphasize, but not in any doctrinaire fashion, that manned space transport is sufficiently complex and costly so that it is not a primary factor in industrially significant space expectations. Indeed the validity of this projection is already seen in the communications satellite field. There, the most commercially significant activity has never involved manned elements.

Fortunately, the very themes that we forward, compatible with the ideas outlined above, involve instrumentation, measurement, sensing, analysis, and systems automation such that the new frontiers of productivity, manufacture, service and quality assurance and reliability will be enhanced. So, indeed, what are examples of these themes of space R&D and exploration which will so directly involve the other needs of our age such as robotics, precision in design and high quality of product for international competition? Well, one case is the characterization and exploration of the extremes of waves and energy in near and far space. If that sounds like astrophysics, that is right, it is. But it is exploration and application of specific, detailed features of near and far space by means of space vehicles closely coupled to earth systems. Then the whole can be related to industrially and economically important phenomena.

We believe that we are ready for the next analytic and technologic phases of probing magnetosphere variation, sunspot, magnetic storms, particle showers and the whole gamut of microscopic substance and functions which fill outer space. Its alleged vacuum and frigidity are but generalizations of remarkable extremes of temperature, pressure and especially particle fluxes of protons, electrons, photons, cosmic rays and others. These we should now probe intimately, with similar intensity to the macroscopic descriptions we have been attempting since the origins of astronomy.

The relationships to new science and technology which are industrially import for the decades ahead is growing steadily. For instance plasmas, which constitute the stars are progessively, being contained on earth.

Plasmas comprise one of the most challenging forms of matter and energy known. As a condition of the stars and especially of our sun, they have of course, attracted scientific study and technical application since the beginning of mankind. We believe, however, that a new period of importance for the study of densely charged particles which are the essence of plasmas is beginning. Plasma behaviour is basic;from fusion energy, the most intense study of plasmas presently under way, through to the influence of the solar wind and the magneto spheric earth plasmas on the weather and on communications, down to the present pre-eminent use of chemical plasmas for the etching and formation of integrated electronics systems. These effects underly important technology and economic advance as well as scientific understanding.

And as we have said, phenomena in outer space offer also conditions for unique study of the bombardment of matter such as meteoric dust, ice particles and other numerous components by these charged particles. The reactions and effects produced by such energetic collisions are also of high interest in the processing of industrial materials, ion implantation and other important processes. Accordingly, in our Laboratories under the leadership of Dr. Walter L. Brown, with the collaboration of Dr. Louis Lanzerotti and several other colleagues now in the general laboratory of Dr. W. F. Brinkman, we have been pursuing active collaboration with the NASA and various space laboratories and universities for more than a decade. Our findings suggest that extended studies by satellite instrumentation and probe in this plasma-field realm are of high promise.

Similarly, we have long worked on the obviously central issue of the propagation of radio waves and other signals in outer space. Following the original discovery of radio astronomy by Carl Jansky in our Laboratories in the early part of the century, we have returned to this topic as improved electronics became available, with the discovery of the maser and other amplifying means. For this recent work Arno Penzias and Robert Wilson received the Nobel Prize a few years ago, but since then we have determined even more molecules in outer space by millimeter waves spectroscopy than have been realized in the earlier telescope and spectroscopic era. Now once more, from the point of view of industrial research and development and economic innovation, the value of these researches embodies a novelty of pressure, temperature and radiation field in which the molecules of the cosmos are found.

For instance, as we have pointed out in projections on the future of chemistry, and as Goldanskii in the Soviet Union has emphasized as well, the reactions of formaldehyde at the low temperatures and highly dilute concentrations in the cosmos suggest electron tunneling. This is a method of forming chemical bonds and rearranging molecules vastly more efficient and versatile than the conventional energy mechanisms used generally on earth.

So now in these ways we see converging the concepts of this brief report. We have said that industrial research and development and a pragmatic use of new knowledge require an exceptional breadth, in comparison to the focus and specific objectives that large public programs usually sustain. This factor was realized in our original participation in the 1958 space policies and indeed in the "space primer" issued by the President's Science Advisory Committee at that time. However, so successful have been the achievements of satellite technology since then, and particularly such elements as the Appollo Mission, that there has been relatively less emphasis on the expansion of scientific knowledge in the magnetosphere and indeed the total "empty space" environ. Now we think this work should be reemphasized. The influence of many of our other major earthly programs, such as energy conversion by fusion, materials processing and the formation of thin film structures aided by implantation and bombardment and vital for electronics, photonics and computers, as well as the whole range of weather forecasting and meteorological understanding in connection with ecological preservation, air pollution and international atmospheres, are,along with many other effects, heavily influenced by the plasma. They relate also to the solar wind which constitutes one of plasma's most interesting forms, the magnetosphere of the earth which determines much of the distribution of and plasma, the configuration and of course, the enormous meteorological weather-determining influence of solar eruptions and other variations of the solar wind. The magnitudes of energy just casually involved in the interaction of the solar wind and the magnetosphere is instructive. This combination forms a huge magnetohydrodynamic dynamo, because of the solar wind plasma cutting the geometric field lines. This dynamo can initiate a voltage drop of 40 to 50 thousand across the magnetosphere, with an accompanying current of tens of millions of amperes. The total power is around 10^{12} watts, which is approximately the electric power consumption (annually) of the United States. This doesn't mean that we have now methods of capturing signficant parts of this energy, but we are literally bathed in it. We have thus an opportunity to pursue the detailed habits of protons and electrons in space and under field conditions otherwise unimaginable.

Our findings of more than a decade of work in this field enable us to report to this Committee that this is an arena of significant technological value, in addition to the profound scientific meanings that it surely contains. Solar flares can propagate protons and electrons to the earth within hours, and sometimes as quickly as ten minutes, although the normal solar wind may occupy three days or more. A billion kilowatt hours can be dissipated in a single magnetic storm. This majestic astophysics and its cosmic energy exchanges are accessible by satellite studies, to become part of the vital data base of knowledge extending the ways we can use plasmas and waves in earth technology.

The Dynamics Explorer Missions scheduled for launch this year, would for example reveal how the earth's atmosphere, with its partial ionization, reacts with a dilute and violent magnetospheric plasma. This field is subject to much speculation regarding weather, and other atmospheric properties, but in addition it can lead to wise design of the older question and new experiments on Origins of Plasmas in the Earth's Neighborhood (OPEN). Such an endeavor would include four spacecraft or so involved to begin to reveal properties of the cosmic plasma thus far only imagined.
We speak with confidence of the vaue of this, because the knowledge of some of these processes on the reliability and the correction of failures of radio propagation and of telephone

and telegraph cable operations have long ago established their significance. Now, however, it is fair to say that from a pragmatic view, important steps in the knowledge of our planet of its mineral and void content, indeed of its planetary morphology, can be gained by appropriately detailed knowledge of its interaction in the magnetosphere.

It is interesting to point out that the corrosion of pipe lines so vital now to the world distribution of energy resources is highly influenced by sunspot activities and the stray currents (telluric artifacts) coming from induced currents up to one amphere, caused by fluctuations in the extraterrestrial fields. In one pipeline system extending from the Atlantic to the Pacific across the Isthmus of Panama, currents could reach 30 amperes, and the direction of flow would reverse from time to time. Since the details of induction of these currents from the magnetosphere are unknown still, neutralizing or other techniques are not yet practical. The Alaska Pipeline of course, traverses the Auroral Regions where the disturbances are 100 times more intense than down in the lower 48 states. The principal origins of disturbances come from currents about a hundred kilometers high above the surface and the highly conducting Alaska Pipeline in grounded through zinc at about 150 meter intervals. It appears that corrosion is well contained, but one is uneasy about the effects on pipeline monitoring and of control circuits and furthermore, and about what unusual and extreme storms could do.

In any case, it is certain that as we study evermore intensively the technical and scientific qualities of earth and attempt to preserve its good hospitality for human kind, we shall need to prove the qualities of the geosphere and the earth's plasma environ.

Mr. FLIPPO. Thank you, Dr. Baker.

In reading your testimony, I found many, many ideas in such a short, concise area that it is very difficult for me to understand all of it. Let me see. Are you suggesting that we should focus on near space more, and does this mean that projects such as the International Solar Polar Mission should have continued, will have to continue at some point?

Dr. BAKER. Yes, sir. You have interpreted this very accurately. By saying "focus on near space more", I of course am not implying anything about the great values of outer space exploration. Those are enormous. What we are saying is, in the spirit of these times, and with the resource constraints that we feel that you have so eloquently described in your opening remarks, we find an opportunity, and indeed a responsibility, for activity in inner space, in the geospace, which is very compelling and very important.

Industrially, I have only touched on the role of these matters. In our notes we accent the fact that corrosion of major resources on earth, pipelines, communication lines, cables, and so forth, are enormously influenced by the plasma we are talking about. Now it is just irresponsible for a nation that could understand that and learn about it by geospace exploration not to do so.

Mr. FLIPPO. Are you saying that we should use the space plasma as a laboratory to study plasma in general, because plasmas could be important on Earth, or are you saying that the space plasma is important to us on Earth and we should try to understand it?

Dr. BAKER. I am really saying both things. That is the intriguing part of this, that plasmas on Earth are of vital importance. You know and your committee is pursuing knowledge of the fusion program, which is in many ways the most exciting energy frontier we are exploring. That is a plasma venture. On the other hand, it turns out, as you have accurately reflected, that the Earth's plasma in the magnetosphere and geosphere is a determinant of vital behavior here, of literally life on Earth through its influence on the weather.

Mr. FLIPPO. I'm interested in your statements about the relationship of government, industry, and the academic community, universities, do you believe that we are currently well organized in this respect? Is our structure adequate to attack these problems as you see them, or do you have some concept of a better arrangement?

Dr. BAKER. I think the Congress, Mr. Chairman, has conceived and articulated our space program superbly over the years. Those of us who had the privilege of helping to draft it in 1958 have been enormously buoyed by the way it has gone, and we think, correspondingly, the executive branch has followed out this structure well, so we don't suggest a drastic shift.

The idea of an independent agency like the NASA (and many other alternatives were considered, of course), the idea of that agency seems to have gone extremely well. We feel its leadership is admirable, it is strong right now, it has been strong over the years, it is combining wise organizational influences. The presence of Dr. Hans Mark as Deputy Administrator as well as of Dr. Beggs as Administrator are extremely valuable features. They have experience in our total space resource domain, from the Defense Department and other relevant agencies, so we really think the structure is good.

Mr. Flippo. The present funding for those programs—and looking down 2 or 3 years at the proposed funding for those programs—it appears that we may not be able to keep all of the disciplines in the program that we would like. Would you have any judgments about our capability to continue, because of the decrease in funding, to have effective programs?

Dr. Baker. I think you have an entirely valid concern. The challenges of science and technology in space are so interesting, so intriguing, so modern, that we are going to be wanting always to have the disciplines widely represented, and to have a large combination of resources.

Now, I understand that our Nation is of course not unlimited in its ability to do that, and therefore we would hope that the idea of combining agency interests, not only DOD but especially NSF, HHS, many other parts of the Government in relevant portions of the space program would be followed up.

There was developed some years ago in the White House science structure a Federal Council for Science and Technology which for a while functioned very well in achieving these disciplinary representations throughout the Government and throughout national programs. We think that needs some reactivation, and what I am really saying is that we agree with you that we cannot combine in the space program all these efforts. But we can relate them together through Government interactions, which, by the way, this committee is very important in stimulating.

Mr. Flippo. Dr. Baker, clearly, as my friend Larry Winn says often, we can't do everything that we can think of to do, but part of our difficulty is trying to find a minimum amount. Consider science and technology expenditures: are they a part of our budget problem or are they a part of our budget solution for the future? Should they be treated the same as other types of expenditures?

Dr. Baker. Mr. Chairman, by minimum you mean perhaps an optimum kind of selection, doing the things which are of the greatest importance, and which I know that Mr. Winn also is much concerned about, and Mr. Brown. I think that systems engineering must be spread as a discipline to permit this selection. I think that we are learning enough about energy, about weather, about bio products, about information, about information in science and technology and a variety of other fields in our economy, obviously energy, materials and others, so that an appropriate systems analysis in each of those fields will help very much in saying what we can and should do first.

Mr. **Flippo**. Thank you very much. Mr. Brown.

Mr. **Brown**. Dr. Baker, I appreciate the emphasis which you place on the scientific value of the near-space program. It seems to me that we tend to neglect the importance of near-Earth, and think that all of the big important questions are way out someplace, and so it's good that your statement emphasizes the complexity and intrigue of some of the problems of near-Earth.

I tend to feel that in visualizing—and I don't do this very often—earth as a sphere in space and after you get past the atmosphere there really isn't anything very much, nothing to see out there—obviously that is wrong. I wonder if you can comment for me about the distribution of energy in the near-Earth environment, to help me visualize this a little bit more.

You have given some examples of the tremendous amount of energy produced by the magnetic fields and the ions in near-Earth surroundings, but is there a gradient? Does that taper off in some fashion? Can you help me visualize it a little bit more clearly?

Mr. **Baker**. Mr. Brown, you are raising a most pertinent issue, because this whole range of interactions we are talking about is much determined by those energy distributions. Now, the outermost section that we can study in this geosphere is the magnetosphere, and there are about three strong energy categories, a few electron volts or a few tens of electron volts at about 20 or less than, up to or less than 20,000 kilometers out, and that is within the plasma sphere.

Then the outer radiation belts themselves that have much higher energies, of course. These go from several tens to several tens of thousands of electron volts, and they extend beyond 20,000 kilometers, but not way into outer space. And then there are, finally, a much scarcer but important population of really high energy protons and electrons from a few hundred thousand to a few million electron volts for the electrons, and a few hundred million electron volts, you are getting us up into the tremendously energetic partical field for the protons.

So you see, we have these broad categories of energies from just a very modest few electron volts to millions and hundreds of millions up to the billion-electron volt range, all represented in the 20,000 kilometer plus or minus region.

Now these particles under those various accelerations interact with other particles, with massive particles. I mean by massive ones the dust of the cosmos, which includes water ice, gas ice, carbon dioxide ice, and those interactions are teaching us a great deal about the nature of matter on Earth and also plasmas.

Mr. **Brown**. In your statement you mentioned some of the driving forces behind the space program, such as security and prestige, and you mentioned a modest but important component of scientific and technical exploration and discovery. I think that is what you are emphasizing in your statement here. The problem with that as a motivating factor is that not many people in the political structure are driven by that to any large degree.

We have to make it very clear and dramatic, I think, what some of the excitement of acquiring new knowledge can lead to in terms of harnessing energy in this country. That has always been a difficult thing to do. I think what this committee is trying to get at is how can we enhance that factor in our own deliberations here in the Congress, in order to get the benefit of it.

You have talked before, I note, of the public and private purposes of research and the public purposes being those that help us solve problems, where the private ones are the ones that basically stem from the curiosity of a scientist. What I am trying to get at here is how we can focus more attention on those programs which harness the curiosity of the scientist and lead us into new discoveries which some day may or may not be helpful to us.

I wonder if you could give us any further comments about that? Although we have labeled this hearing a pragmatic discussion, one of the essences of pragmatism, I think, is learning how to create excitement and challenge. I want all the ideas we can get from you on that.

Dr. BAKER. Mr. Brown, you are very astutely identifying what I think the opportunity is in this field of geospace. Namely, we can generate the intellectual excitement, the attraction for curiosity, by supporting university and educational research and teaching in this field. And at the same time that we do that, we can be assured that it is going to converge in the most pragmatic way on the industrial and governmental use of that knowledge. We have said that plasmas and other features of the geospace are vital in the decades to come for some of the major aspirations we have in this country.

At the same time, we can be assured that along the lines you are citing, that if we support the academic and basic science ventures in near space, in the kind of geospace that we are talking about, we are going to be cultivating generations of people who will have just the animation that you are properly reminding us of, and that is where the whole key lies.

That is where the investment of this Nation in the space program is of such enormous value. It is a treasure, because you have got generations of young people coming on who are excited about the activities there. They have obviously been excited by the far space, and Saturn ventures and all the rest, which are going to carry on for some time. But what we are reporting this morning, as your chairman has identified, is that there are other arenas, too, rather modestly demanding in their facilities and in their ventures. They will do just what you are suggesting also, and they will excite knowledge of plasmas, of the interaction of charged particles with matter, of the whole movement of highly ionized structures, and they will help new industry, new values and capabilities.

Mr. BROWN. That is the point that I wanted to reemphasize. You have emphasized it very well. We had an exciting presentation yesterday from a young man who said he was so thrilled and stimulated at the age of 10 by the lunar landing program that he became a space engineer, and that testimony was excellent.

But the stimulation was what you would call a space spectacular, I think, as much as anything. What I would like to see is a balance in which we stimulate the imagination of the American people and the American political leadership with an awareness not only from space spectaculars but from the pragmatic challenge of acquiring the new knowledge that can be so important to us in the future that you have laid out so well.

Dr. **Baker**. You are so right in putting it in those terms, and of course there are magnificent visible features of this phenomenon we are talking about, the aurora, the whole issue of the ionosphere and its effect on lightning and other great effects on Earth. But we have not got the detailed science that you are calling for yet.

Mr. **Brown**. Thank you, Doctor.

Mr. **Flippo**. Mr. Winn.

Mr. **Winn**. Thank you, Mr. Chairman.

Dr. Baker, a little bit of a different direction. I think because of budget cuts under the present administration, many of us are looking for a criteria for a reasonable balance between what the Government spends and what industry spends, and who will benefit from the proceeds other than the American people, we hope, in the long run. Do you have any ideas on how we develop that criteria other than possibly hearings of this type?

Dr. **Baker**. Mr. Winn, I think in the final answer these hearings are one of the best methods of doing it, and we believe the structure of these present ones has been particularly fruitful. For example, I think it is emerging from what I have seen from your record so far and what you have planned, that industry and private resources are going to be increasingly effective in the construction, design, operations of the space vehicles themselves, and of the interpretation of their findings.

For example, if space vehicles invade the geospace the way we are talking about, as they have already, both academic—and I think that is a very important part of it—and industrial interpretations will take place. In some decades ahead this will turn into a highly technological and industrial application of our plasma work. But I think at the same time the launch and maintenance capabilities do not seem to be appropriate for nongovernmental support. We simply have not found ways to make those effective, and you brought that out at some of the current hearings.

So I would report that we have been concerned about this, and our earliest work in the communications satellites and the initiation of that era with Echo, Telstar, and successors, we of course tried very hard to see what the industrial role in launching and in rocketry might be. We have had many responsibilities in our own laboratories for rocket design and operations in defense systems, and I must report that we still do not have an appropriate role for nongovernmental activities there. It is just expensive. It is high risk. It has environmental and general public implications. I think that is the kind of division that we see shaping up, Mr. Winn.

Mr. **Winn**. Along the same line, are there any criteria that you know of, any studies that have been made, which can be used to assess the value of the space program as opposed to other nonspace programs?

I think in our budgeting, as we look down starting today and tomorrow and the next day in every program, we are talking about the space program, we are going to have to see if we can maybe develop a criteria to help compare government expenditures in the space program against the nonspace program. You hear that debate every hour on the hour.

Dr. **Baker**. It seems to me you are developing in these hearings and in some of your other studies a framework for those criteria. You have certainly brought out very accurately—and this is a thing that Mr. Brown has pursued over the years as well—the fact that in space we have the very important defense elements, vital defense elements. We have, second, the vital public enthusiasm elements, which he was speaking eloquently about a minute ago, as the chairman brought out. Those are two very large things that, as you say, you have to weigh in terms of cost and the rest.

Now the third one, which we are concentrating on at this moment, is the science and technology. There I think the criterion for support can be quite definite. It is to trace through, in the systems engineering way were talking about, what the relations of space findings have been to parts of our economy and of our public capabilities, of our public service in a broad sense.

It seems that the weather, the energy implications of the geospace, the importance for the whole electromagnetic surroundings of life, literally what controls much of it, what controls corrosion on big structures, the communication fadeout of radio, a lot of other things which are highly technological but highly economic—those things come from effects of the geospace. The control of them and the modulation of them comes from the depth of our knowledge about geospace.

So I believe that we do have a reasonable set of criteria, knowing the values, which I won't try to bother you with now, of those indutries that are dependent on the things I have mentioned. They are enormous. They relate to a large fraction of our gross national product—the reliability of communications, for example. But with knowing what those are, I think we can form some reasonable judgments in the ways that you have cultivated in these operations, for how much money ought to go into the space part of it.

Mr. **Winn**. In a little different vein again, since I was a former delegate to the United Nations in 1979, and one of the subject matters was international space. What do you think should be our role, first, and the role of the U.N., in international space cooperation?

Dr. **Baker**. I think the role of the United States, Mr. Winn, ought to be of unqualified leadership. The curious position of our earth in the cosmos, with its security and science and technology implications, which many of us have devoted so many decades to, is such that we must have, we must seek unqualified leadership. With respect to the U.N. positions, the spirit of that great ideal can be advanced enormously through such things as global satellite communications resources that the U.N. sponsors.

We, a year or so ago, designated in the Marconi Fellowship Professor Pal of India for his historic contributions to receiving satellite communications programs for education, for knowledge, for art, for comfort, through at the populations of the subcontinent of India by the use of chicken wire antennas. These he figured out with great ingenuity, now there are broadcasts available to villages in India, that have no links with the rest of the world of any kind of normal forms, wire, cables, radio, whatever. And this is symptomatic of the opportunities that space capabilities have in the ideals of the United Nations for a peaceful and progressive world. But I think the United States has got to take the lead.

Mr. **Winn**. If we take the lead, and we probably have it now at this stage of the game, how far should we go in sharing our technology before it begins to bite us in the rear end?

Dr. **Baker**. Mr. Winn, this certainly doesn't resolve the issue.

Mr. **Winn**. As far as competition is concerned, where they catch up with us.

Dr. **Baker**. You are bringing up an enormous philosophical and political question which I have had the privilege of commenting on before your committee, as Mr. Brown will remember, in earlier years, because solid state electronics is a primary case of what you mention. There the United States shared with the rest of the world its findings and its science, so that now our most severe competition comes from other hemispheres.

The same thing, doubtless, may happen with space science and engineering. But it seems to us that the spread of knowledge and of learning and of civilization simply demands that we do share it. Now you have a very significant subissue in your broad query, and that is in security affairs we must be absolutely self-centered and contained in our use of space.

We believe that President Eisenhower and some of his successors' definitions of the peaceful use of outer space were entirely appropriate and are enduring. We can work that out, so that the sharing part will not impinge, and weaken the absolutely central security parts. These are being pursued with great vigor and great success.

Mr. **Winn**. The U.N. is certainly not the greatest place to feel secure about your own security, I will guarantee you that. Thank you very much. I enjoyed your comments.

Mr. **Flippo**. Mr. McGrath.

Mr. **McGrath**. Thank you, Mr. Chairman.

Dr. Baker, welcome. I would like to perhaps take off on the questioning of Mr. Brown and also Mr. Winn. Some years ago, when you were the head of Bell Labs, I am not quoting you, but you said, "I need a transistor every 10 years." That may not be an accurate quote, but I guess it was referring to the need for a visible success every so often in order to generate support for basic research. Can you comment on that as it pertains to our programs?

Dr. **Baker**. Mr. McGrath, your gracious references are very timely. By the way our laboratories did respond to that particular need. About 10 years after the transistor came the masor and the laser, and about 10 years after that the charge-coupled devices and the "big bang" measurements of the universe, and many sorts of automatons. So all we are saying there is that that is not an unreasonable expectation for any science and technology program. Nature is simply beneficent with its knowledge and with the opportunities there are in it.

Now, I believe, correspondingly, it does apply to the probes that you are making, the ways you are looking at our future space activities. You have on behalf of the American people a right to expect and to demand, as your chairman has implied in other connections, very important progress in discovery, when the people are putting as much money in as they are into space science and engineering.

As Mr. Winn has pointed out, we already have to be selective about how those resources get used. But my most pertinent answer to your very thoughtful query, is that, yes, we do have a right, we the American people, to expect success of a rather striking magnitude in the explorations of space that we are now looking forward to.

The geospace realm that we are talking about is going to be an important example of that, if we pursue it. For instance, Dr. Brown and his associates, Dr. Walter Brown—all important space scientists are named Brown in some form—is finding that the impact of these high-energy particles with ice fragments, all kinds of ice in outer space, are yielding molecular rearrangements, atomic rearrangements in those particles an order of magnitude more extensive than was expected.

The obvious implication of this, that he and others are pursuing in this field, is that there are possibilities for life generation, for complex molecule generation in this interaction of the plasma sphere and particles containing carbon, hydrogen, oxygen, and other things. These we simply have not explored before, much we haven't known anything about. I am not able to say that somebody is going to get a key result for the secret of life in the cosmos from those studies, but it is a kind of expectation to have in the back of one's head.

As we note in our report to you, the formation of plastics and polymers is one of the great triumphs in our century and one of the great economic strengths of our country. Now, that involves putting a lot of molecules together. It has been noted that the polymerization of formaldehyde, one of the important molecules that we have discovered in geospace and in outer space as well, seems to occur by electronic tunneling without the normal chemical obstacles which we have to counter on Earth. Possibly further exploration will show how that happens.

It is a long answer but I think an emphatic one to your point.

Mr. McGrath. I think we do have a high expectation for our program, and I think perhaps some of the announcements that came over the radio today regarding the delay of the Shuttle sort of lowers those expectations to some extent. Let me just take off my hat to my colleague from Kansas, Mr. Winn, who I think was referring to the budget and who should be in the field. Certainly, we have a defense need and capability in space.

Certainly, we have demonstrated a civil need, civil and governmental need and capability in space, and there are those who would like for us to farm out some of the NASA activities like weather sensing and geological sensing to private industry. I am just wondering whether you would comment on those needs that we have, and whose responsibilities they ought to be.

Dr. Baker. Mr. McGrath, as the chairman noted earlier, the question of organization of the present Federal program is vital in your point.

Mr. McGrath. Excuse me. In light of the realities—the realities, namely, are that defense can just get anything that it wants today except maybe a few dollars that are going to be cut. NASA is having a tough time struggling to get what it needs to maintain an ongoing program, and then there are those outside private entrepreneural enterprises and people who would like to take away some of the activities that NASA and NOAA are presently operating. I am just wondering what you think about the extent to which we ought to let Defense and the Comsats of the world take away from the civil activity of NASA.

Dr. **Baker**. It seems to me you are giving the right response to your own query. As I said, the question of organization of NASA or the whole space issue came up. The defense part certainly needs to be separate and is being handled very adequately, but we think that the combination of disciplines that Mr. Flippo mentioned, we have emphasized are essential. The role of industry and the private sector along with the Federal sector, those things are assured by the NASA structure that is in place now. That structure, to come to your specific issue, does encourage a large part of industry and the independent sector in universities and other enterprises to participate, and we think that that will grow. The important thing, I think, legislatively and administratively, is to reduce the obstructions to participation, to enhance the very good relationships that NASA has already established with the independent sector in the country.

Mr. **McGrath**. I am convinced that, if left alone, the relationship between local governments, state governments and universities would go on in a fashion which both have enjoyed. But if we were to parcel it out to private enterprise perhaps they wouldn't, because there would be a need to make some sort of money on the enterprise. I am just wondering how you feel about that.

Dr. **Baker**. As we pointed out in our notes, the profit sector, the industrial sector in which we work, has to build its science and engineering on a very broad base. That is sometimes understated.

You just can't pick up an item which might be a weather-monitoring system or a forecasting technique, depending by the way on improved evidence from geospace, you can't pick that up and turn it into a profitable enterprise without a very broad technological and scientific foundation. That has got to come from universities and from research and development laboratories, and from Government input.

So we think that the NASA is a good way to coordinate these activities, to give the independent enterprise the breadth of foundation that it needs to go ahead and do its profitmaking service. At the same time, we need to give the foundation-creating enterprise, that is, the Government and especially university parts, the support they need to form the foundation in the first place.

Mr. **McGrath**. Thank you, sir.

Mr. **Flippo**. Mr. Lowry.

Mr. **Lowery**. Thank you, Mr. Chairman.

Dr. Baker, in the areas of science, what do you think NASA should be concentrated on both in your near term as well as the longer term, and if we apply the budgetary restraints as we are experiencing at least for the time being, how does that impact your answer?

Dr. **Baker**. The idea of how these budget constraints can be worked in?

Mr. **Lowery**. Where do you see NASA concentrating in the areas of science, near term and long term, and how do these budget cuts impact your answer in terms of where our focus should be?

Dr. **Baker**. We fear, of course, that the impact on the long term will be especially disturbing. The budget process must deal with as near to certainty, I presume, as one can get. And we do submit to you, and that is one of the great strengths of this committee, that you realize how levels of certainty change, and the long-term science and engineering does not have a high level of certainty. It is a high-risk venture. It is something that a budgeteer finds intangible, elusive, unreal in many forms.

We, therefore, believe that we can only point toward the record of what science and technology have already done in concrete economic terms, which you all know very well. This we have reported to other committees of the House quite recently, portions of our gross national product that come from modern work in the laboratory. Those things have to be the basis for budgeting for the space program for the future, but it is that record that leads us to submit to you a reasonable confidence that such things as scientific explorations, the long-term scientific exploration of geospace will be valuable and will pay off in the times ahead.

Mr. **Lowery**. Would the specific areas that you see us concentrate on, possibly the interactions of the Earth and Sun, telecommunictions, remote sensing—where do you see us focusing?

Dr. **Baker**. Well, that is an important one. Now, that is a fairly near-term one, this question of reliability of communications and their control and improvement by the understanding of geospace, of sun flares, of radiation bursts and the like. There is just no question about that paying off. We have also noted that in some of the Nation's and the world's most ambitious projects for distribution of energy, which involve on the one hand pipelines for gas, oil, eventually coal suspensions and the like, and on the other hand cables and conduit structures for electric current distribution, those things are enormously influenced by knowledge of this magnetosphere and of the perturbations that can occur there, so the payoffs in that field are petty tangible.

Beyond that, we have to emphasize the role of plasmas and of plasma science in many of the new ventures for commerce and industry. We have cited those for film preparation, film pattern structure. We can recall that in addition to the fusion reactor, which is a star on earth and which may be the most prominent possibility for energy in the next century, in addition to that, magnetohydrodynamics, which you remember was an energy-generating possibility of great promise a few years ago, and which hasn't been exhausted by any means, is a technology of plasmas. In competition, we know other nations, the Soviets, people in Asia and other places are pursuing that effort pretty vigorously. Our knowledge of plasmas is simply going to apply rather immediately.

Mr. **Lowery**. Thank you, Doctor. Thank you, Mr. Chairman.

Mr. **Flippo**. Dr. Baker, thank you very much for your excellent testimony. We are most appreciative.

Our next witness is General Tom Stafford. He is another person that is very familiar to the Committee on Science and Technology. He made four spaceflights as a civilian astronaut, and then continued his distinguished career in the Air Force, where he led the Air Force's programs in research and development. With this background he is especially qualified to help us with the balance between military and civilian programs, and he is also, I learned this morning, a great photographer. I believe he took the picture, the second one on the wall over there, and it is indeed a pleasure to have you here, a man who truly needs no introduction. Please proceed.

[A biographical sketch of General Stafford follows:]

BIOGRAPHICAL DATA

NAME: Thomas P. Stafford, Lieutenant General, USAF (Ret.)

BIRTHPLACE & DATE: Born September 17, 1930, in Weatherford, Oklahoma. His mother, Mrs. Mary Ellen Stafford is a resident of Weatherford.

PHYSICAL DESCRIPTION: Black hair, blue eyes, height: 6 feet; weight 175 pounds.

EDUCATION: Graduated from Weatherford High School, Weatherford, Oklahoma; received a Bachelor of Science degree from the United States Naval Academy in 1952. In addition, General Stafford is the recipient of several honorary degrees. These include a doctorate of science from Oklahoma City University; a doctorate of laws, Western State University, Los Angeles, California, doctorate of communications, Emerson College, Boston, Massachusetts; a doctorate of aeronautical engineering, Embry-Riddle Aeronautical University, Daytona Beach, Florida, and a doctorate of humanities, Oklahoma Christian College, Edmond, Oklahoma.

MARITAL STATUS: Married to the former Faye L. Shoemaker of Weatherford, Oklahoma. They have two daughters, Dionne Kay and Karin Elaine.

RECREATIONAL INTERESTS: His hobbies include hunting, soaring, weight lifting, and swimming.

ORGANIZATIONS: Fellow of the American Astronautical Society, American Institute of Aeronautics and Astronautics, and Society of Experimental Test Pilots, and a member of the Explorers Club.

SPECIAL HONORS: Awarded two NASA Distinguished Service Medals, two NASA Exceptional Service Medals, the JSC Certificate of Commendation (1970), The Air Force Distinguished Service Medal with 3 Oak Leaf Clusters, the Air Force Command Pilot Astronaut Wings, and the Air Force Distinguished Flying Cross. Other awards presented to General Stafford include the American Institute of Aeronautics and Astronautics (AIAA) Chanute Flight Award, the Veterans of Foreign Wars National Space Award, National Geographic Society's General Thomas D. White USAF Space Trophy, Federation Aeronautique Internationale Gold Space Medal. In 1966, he was co-recipient of the AIAA Award. He was honored with the Harmon International Aviation Trophy in 1966 and again in 1976. In 1969 he received the National Academy of Television Arts and Sciences Special Trustees Award and in 1978 the Los Angeles Area Chamber of Commerce Kitty Hawk Sands of Time Award; received the Society of Experimental Test Pilots James H. Doolittle Award for Management, September 1979; October 1979, received the NASA Medal for outstanding leadership, one of the Agency's highest awards.

EXPERIENCE: Stafford graduated with honors in 1952 from the U.S. Naval Academy, Annapolis, Maryland, and was commissioned a second lieutenant in the United States Air Force. General Stafford received his pilot wings at Connally AFB, Waco, Texas, in September 1953. He completed advanced interceptor training and was assigned to the 54th Fighter Interceptor Squadron, Ellsworth AFB, Rapid City, South Dakota. In December 1955 he was assigned to the 496th Fighter Interceptor Squadron, Hahn Air Base, Germany, where he performed the duties of pilot, flight leader, and flight test maintenance officer, flying F-86Ds.

Upon returning to the United States in August 1958, he attended the Air Force Experimental Flight Test Pilot School at Edwards AFB, graduated in April 1959, and received the A.B. Honts award as the outstanding graduate. He remained with the school as an instructor and later as chief of the Performance Branch.

In this capacity he was instructor in flight test training and specialized academic subjects--establishing basic textbooks and directing the writing of flight test manuals for use by the staff and students. He is co-author of the Pilot's Handbook for Performance Flight Testing and the Aerodynamics Handbook for Performance Flight Testing.

General Stafford was selected among the second group of astronauts in September 1962 by the National Aeronautics and Space Administration (NASA) to participate in Projects Gemini and Apollo.

In December 1965 he was the pilot of Gemini VI which was the first rendezvous in space and helped in the development techniques to prove the basic theory and practicality of space rendezvous.

In June 1966 he was commander of Gemini IX and performed three different types of rendezvous including a demonstration of an early rendezvous that would be used in Apollo; the first optical rendezvous; and a lunar orbit abort rendezvous.

From August 1966 to October 1968 he headed the mission planning analysis and software development responsibilities for the astronaut group for Project Apollo.

General Stafford was the lead member of the group which helped formulate the sequence of missions leading to the first lunar landing mission.

He demonstrated and implemented the theory of a pilot manually flying the Saturn booster into orbit and the translunar injection maneuver.

General Stafford was commander of Apollo 10 in May 1969, first flight of the lunar module to the moon, performed the first rendezvous around the moon, and performed the entire lunar landing mission except the actual landing.

He also made reconnaissance and tracking on future Apollo landing sites. Stafford was cited in the Guiness Book of World Records for the highest speed ever attained by man which occurred during Apollo 10 re-entry when the spacecraft attained 28,547 statute miles per hour. This set the world's all time speed record.

He was assigned as head of the astronaut group in June 1969 and, as such, was responsible for the selection of flight crews for Projects Apollo and Skylab.

He reviewed and monitored flight crew training status reports, and was responsible for coordination, scheduling, and control of all activities involving NASA astronauts.

In June 1971 General Stafford was assigned as Deputy Director of Flight Crew Operations at the NASA Manned Spacecraft Center. In this role he was responsible for assisting the director in planning and implementation of programs for the astronaut group, the Aircraft Operations, Flight Crew Integration, Flight Crew Procedures, and Crew Simulation and Training Divisions.

He logged his fourth space flight as Apollo commander of the Apollo-Soyuz Test Project (ASTP) mission, July 15-24, 1975 · a joint space flight culminating in the historic first meeting in space between American Astronauts and Soviet Cosmonauts.

The event signaled a major advance in efforts for the conduct of joint experiments and the exchange of mutual assistance in future international space explorations.

His military decorations and awards include the Distinguished Service Medal (Air Force design), Distinguished Flying Cross with one Oak Leaf Cluster, Air Force Commendation Medal, Air Force Outstanding Unit Award with on Oak Leaf Cluster, the NASA Distinguished Service Medal, and the NASA exceptional Service Medal (twice).

He has logged 507 hours and 43 minutes in space flight and wears the Air Force Command Pilot Astronaut Wings. He has flown over 110 different types of aircraft and has over 7100 flying hours.

General Stafford assumed command of the Air Force Flight Test Center November 4, 1975. He was promoted to the grade of Major General August 9, 1975, with date of rank of June 1, 1973.

Promoted to grade of Lieutenant General on March 15, 1978 and on May 1, 1978 assumed duties as Deputy Chief of Staff, Research Development and Acquisition, Headquarters USAF, Washington, D.C.; retired from the Air Force November 1, 1979.

General Stafford is currently Vice-Chairman of Gibraltar Exploration, Ltd. in Oklahoma City, Oklahoma and Chairman of The Board of Omega Watch Company of America, New York City, New York. He is a member of the board of several financial institutions and oil and gas exploration companies.

STATEMENT OF GEN. THOMAS STAFFORD, USAF (RETIRED), FORMER ASTRONAUT, FORMER HEAD OF THE USAF SPACE PROGRAMS

General **Stafford**. Thank you, Mr. Chairman, Mr. Winn, other members of the committee whom I have known for so long. It is really an honor for me to be here to testify before you on this most important subject. It is somewhat a new experience to me, since this is my first testimony as a private citizen, sir.

I have previously submitted an expanded written testimony which is available, and also today I will be somewhat pragmatic in looking at the near term. I am the vice chairman of a small oil and gas exploration company, and if we don't get more producing wells than we do dry holes we will soon be out of business. With that, I would like to go into what I can perceive as a reasonable scenerio for the space program as we know it for the next 50 years, and provide a few thoughts possibly as to what we can do now to help that future unfold.

As we know, 50 years is an extremely long period of time, and I feel it will be dynamic in space exploration but by breaking it down into small segments we may be able to do a credible job of looking at it. The space shuttle is the real key to the future in the same way that the Wright brothers' first airplane was a key to aviation. While the growth of the space program may be unique, I think it will probably be somewhat a parallelism to what we have experienced in aviation.

First, the decade of the 1980's, no doubt, will be the first decade of the shuttle era, and it is in this period of time that the shuttle will reach its first operational status. It will probably be no more than really a booster carrying payloads for this period of time, in this decade, but we do need to have efforts in the space shuttle to expand its capability, and I don't mean just pure launch cabilities as far as payload.

One of the great problems we are going to have with the space shuttle, like the problem we have experienced yesterday at the Cape, is to make the shuttle operable. There needs to be in the 1980's a product improvement program on that space shuttle, like the same improvement programs we have had with many aircraft, whether it is a commercial plane like a 727, a DC-10, DC-9 or many of our military planes like the F-15B, C, and D. You are going to have to do that with the space shuttle to make it operational, but as we continue to expand the product improvement program it will become more and more operational.

Then during the decade of the 1990's, the space shuttle will finally begin to fulfill its promise. The original limitations that we are seeing today should be overcome, and the operation should become rather efficient.

With that in mind I will go into just in a couple of minutes of what I think is a challenge for this committee, for members of the Congress and the administration to rereview the infrastructure as to how we operate in outer space. Where do we go and what is the bottom line, and the most efficient way for the United States to maintain its eminence in space?

The serious research and development efforts of the space program with the shuttle as a testbed will pay dividends. I envision, in the nineties that we will take the first steps toward a long-term on orbit space station capability using modules put there by the Space Shuttle. These are activities that we will develop from the operational shuttle in the nineties, starting with a low earth orbit operational station, will give us the background for an expanded capability in the 21st century.

Then perhaps the first 30 years of the 21st century will see men—and when I use the word "men," Mr. Chairman, I include ladies—be permanently in space on working platforms both for civilian and military programs.

I would envision that these large space platforms will take several forms. Some of the platforms will be mission oriented for military efforts, some will be pure research and developmental experimental laboratories in the civilian sense, and others will serve as a logistics base to provide a total logistics support for permanent orbital activity. The 21st century will probably see men go back to the Moon, in this case probably for more practical reasons. Also, there will be the beginning of manned planetary exploration during the later part of third decade in the 21st century.

All this leads us to the problem that we will need to expand far greater launch capabilities than we presently have. We will need to place extremely large amounts of material into orbit and then, once in orbit, to maneuver these materials and structures into even higher orbits. We need to examine new types of energies for our launch efforts. We are presently at the upper limits of the pure chemical type of launch, and there are new types of ideas of energy that should be explored.

When we review these efforts that I have described which is just a summary, since I have expanded more in my written testimony for that period of time. What shall we do to make these things happen? First we need a very vigorous research and development program. Here we should build on our strengths that we have developed so far, and NASA should continue to carry out its research and development which they do so well. Agencies like the Air Force and others, where appropriate, can transform that R. & D. activity into an operational system that will be needed in the first part of the 21st century. That same philosophy would apply over a whole range of disciplines.

One thing that I mentioned earlier that I can't emphasize enough is this product improvement program. The Space Shuttle was developed as NASA's really first operational system. As we all know, it was developed in an era of very tight fiscal constraints, and the problems that were postponed during the research and development program are going to show up in the operational area and will need to be corrected. They will take the same efforts in the same manner that you start an aircraft development program and evolve into an operational airliner or a military system. The word "operability" needs to be greatly emphasized.

I had mentioned the requirement for advancement in propulsion technology, particularly during the first part of the 21st century. This is required in order to get more energy efficient than we have today with pure chemical propulsion, both solid and liquid.

In the 21st century we must also pursue energy-producing technologies. Today's energy problems results primarily from the disruption of the distribution system rather than a lack of energy reserves. However, all of us can foresee that in the early part of the 21st century that some of our fossil fuels will be nearly exhausted, not all of them but some of them, some of the easiest to work with.

From there you can envision possibly large solar collectors bringing energy back to earth. However, this is somewhat of a brute-force approach to the problem, which uses today's technology to solve a problem in the future, but there may be some technologies where priorities need to be given.

Finally, we must stimulate commercial and industrial activities in space. There will be new technologies and new areas for the industrial and the private sectors to participate in. These participations will be a requirement to help us maintain our future efforts in space.

In reviewing my experiences, I remember when I testified before this committee in 1975, when Mr. Teague was the chairman. The one area that I emphasized that we needed in the United States was a continuity of our programs, Mr. Chairman, and not the peaks and valleys that we have undergone for so many years. Unfortunately not just one house of the Congress can solve it, neither can the administration by itself. It is a total problem involving the legislative and administrative branches of our Government.

I would like to emphasize what Mr. Brown brought out, that we need to communicate what are these long-term goals in order to obtain public support. The one area where I think NASA has failed in the past and so has the DOD is in communication. How do you communicate what needs to be explained to the public? All of you are directly involved in communications, because if you don't communicate properly, you don't come back in 2 years.

The support of a long-term program is one that requires a lot of effort on NASA's part, on the DOD's part and on the Congress part to tell the people, the American public, in a logical way, that the money for research and development is going to be the final payoff. That is a very difficult problem, Mr. Chairman, but it is one that certainly needs to be addressed. I know that Chairman Teague was very frustrated by this item on many occasions. I have also talked to Mr. Winn about the inability to explain these goals in a way that would generate public support.

Finally, having worked as an astronaut and the head of Air Force research and development, I am one of the few people in the world that had an opportunity to observe the Soviet Union's space program firsthand. The one thing that has impressed me is, the continuity of their program, their commitment for a long-term growth, and there seems to be a void of ups and downs. We need to really examine that aspect. We always tend to leap-frog them in certain areas of technology, but then slow down.

In my own view we have to keep this country preeminent in space in the 21st century in order to have the same standard of living and the freedoms we have enjoyed. I am confident, with the right leadership and the right vision we can do that.

Mr. Chairman, that completes my formal statement.

[The prepared statement of General Stafford follows:]

STATEMENT FOR THE RECORD

THOMAS P. STAFFORD, LT GEN, USAF (RET)
TO THE COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
WASHINGTON DC
SEPTEMBER 23, 1981

Good morning, Mr. Flippo and Members of the Committee. I am Tom Stafford and it is a great pleasure for me to be testifying before your Committee this morning. This is a somewhat new experience for me since this is my first testimony as a private citizen. As you know, I have had a rare opportunity to serve my country both as an astronaut on four space flights, and as an Air Force officer with my final responsibilities including all Air Force Research and Development. I am presently the Vice Chairman of Gibraltar Exploration Limited which is a company actively engaged in the exploration for new energy resources here in the United States.

With this background my perspective may be somewhat different than that which you will get from your other witnesses; I hope my views will be helpful to you as you deliberate upon our future course of action. With your permission I will first discuss briefly what I think is a reasonable scenario for our next 50 years in space and then I will provide a few of my thoughts about what we can do now to enable that future to unfold.

Fifty years is an extremely long time, particularly in a field as dynamic as space exploration. However, I believe that if we break it down into smaller segments that we can make some reasonable projections. The Space Shuttle, of course, is the key to this future in the same way that the Wright Brothers first airplane was the key to aviation. The pattern of growth and expansion during the space era will undoubtedly be unique, but I suspect that in historical perspective that it will be rather similar to the pattern we have seen in aviation during this century. One caution, however; we must not lose sight of our objectives; the Shuttle itself is simply the means by which we explore the space medium and is not the end in itself.

The 1980's will be the first decade of the Shuttle era. During this time the Shuttle will reach an operational status and cease to become a research curiousity. We will use it conservatively. In fact, during this decade it will be little more than a larger booster to carry payloads much like we've carried in the past into space. This will be a time when the Shuttle limits are more important than its potential, and those limits will need to be overcome before we can really expand our capability. This will also be the time when the Shuttle demonstrates that it is a dependable vehicle and the confidence of the user community -- both civil and military -- will grow significantly. By the late 1980s there will be significant pressure for greater Shuttle capability -- particularly from the Air Force -- as their knowledge of the Shuttle and their confidence in it increases. We will also begin to learn what men can really do in the space medium on a routine, recurring basis. This manned activity will be, of necessity, rather limited during this time and may occasionally appear as a curiousity in the overall space program; but these first steps will be extremely important in preparing for what will follow.

During the decade of the 1990s the Space Shuttle will begin to fulfill its promise. By then the original limitations will be overcome and Shuttle operations will become reasonably efficient. Indeed, during this decade we will begin to reach the limits of Shuttle capability. Men will be in space performing useful functions during this time. Serious research and development using the Shuttle as a test bed should begin to pay real dividends; we will begin in earnest sequences of satellite replenishment and on-orbit repair; and finally, we will take the first steps toward a long-term on-orbit capability with demonstrations of construction of large space stations or other orbiting structures. These activities will lay important groundwork for an expanded space capability in the 21st century.

The first 30 years of the 21st century will see man permanently in space working on orbiting platforms for both civil and defense uses. I expect these large platforms will take several forms. Some of them will be mission oriented; others will serve as logistics bases to support a broad range of permanent orbital activity; and we may even begin to see the deployment of space-based power collection and distribution systems. During this time men will take their first steps out away from the earth toward the planets.

The 21st Century will probably see men go back to the moon -- in this case for practical reasons. I expect when we ask the question "wouldn't it be cheaper to get lunar minerals for space station construction?" the answer could be "yes", although it will be many years before this question is resolved. And so the moon may serve as an important logistics base. We may begin manned planetary exploration during this period, but I expect our primary concentration will be on the earth and improving the quality of life here.

All of these exploratory activities will demand far greater launch capability than we expect to have with Space Shuttle. We will need to place extremely large amounts of material into orbit, and then once in orbit, be able to maneuver realtively large structures to higher altitude orbits where they will perform their missions. During this timeframe the Space Shuttle, and its manned and unmanned derivatives and successors, will routinely perform missions which require multiple launches and on-orbit rendezvous and the assembly of large complex space structures. However, relatively early in the 21st Century I expect we will begin to be severely constrained by our launch energy and we will need to look for new approaches.

This has been only one of a number of possible perspectives that I could take on how our future space activities will develop. I don't believe it is particularly important that my guess is more or less accurate than someone elses guess. What is important is that space applications will grow and expand, much as aviation has grown and expanded, and we must lay the groundwork now if this is going to be able to happen. I've broken the following discussion into several major areas.

NATIONAL GOALS IN SPACE

A vigorous U.S. space program has been established in the last three decades. It provides the base to capitalize on the opportunities of the new era which lies before us.

Renewed emphasis and clarity of focus are required in our national space effort to enhance our economy, to revitalize our technology, to contribute to scientific knowledge, and to improve our defense. The sum of our future space efforts will increase national pride and recognition of this nation's preeminence in technology and enhance our national capabilities.

The applications of space technology permeate nearly all aspects of our domestic and international activities. Japan and Western European countries are becoming serious commpetitors for communications satellites and for launch vehicles.

The Soviets are pursuing a space program which is continually expanding in capabilities. They develop and apply space systems to many military functions, reconnaissance, surveillance, communications, and navigation. They develop and test anti-satellite systems which threaten U.S. satellites in low earth orbit and conduct research into directed energy weapons which may become a threat to our satellites. They conduct a continuing successful program of man-in-space activities which contribute to the Soviet position as a superpower.

A substantial space program is not only essential to national defense, but it is also important in many civilian areas; such as communication, weather, and earth resources. The space program typically operates at the very frontier of technology and spawns technological advancements. The private sector should be provided greater opportunities and incentives to support an increasing share of the effort. Our leadership in space exploration should be supported and new opportunities exploited for science and national prestige.

The successful operation of the Space Shuttle opens a new era in space. It allows us to achieve the goals of the future with a substantially different perspective, ease and economies if we adjust properly to this new opportunity.

INDUSTRIALIZATION & UTILIZATION

In the past, space activities have been important, even spectacular, but not a major part of the day-to-day life of most of earth's people. In the very near future the opportunities will exist for space to make a major difference in the future of mankind. The areas of major impact are information management, global environment and resources management, and products made in space.

Space unquestionably has overwhelming advantages for communications: a single satellite at geostationary orbit has line-of-sight access to a whole continent. The technology will soon exist to use this vantage point to communicate directly with millions of small, inexpensive, portable ground units. With the projected increases in world population, the need for education, information and communications will increase dramatically.

The use of satellite technology, particularly in remote locations and less-developed nations, is based on economics. The cost of hardware necessary to handle a satellite voice circuit has dropped dramatically since 1966. An Early Bird voice circuit cost more than $20,000 per year; today Westar provides equivalent voice circuits for a little over $200; and large multibeam antennas launched by the Space Shuttle soon could bring about further cost reductions, possibly as low as $20 per circuit year. With costs at this level, a number of previously unavailable communications services should emerge. Continued commercial communications satellite growth will lead to crowding of the geostationary orbit and a frequency spectra and points out a need for higher capacity systems.

There is also a need for methods to replace energy-inefficient modes of information exchange. A collection of communication services on large geostationary satellites or platforms could make such substitutions possible. Audio, facsimile and video teleconferencing by satellite could be used in place of travel to business meetings.

Implementation of communications capabilities on a scale sufficient to provide significant benefit demands large space systems. Large antennas and power modules in space will allow the use of simple, widely affordable individual terminals on the ground. Multiple antennas and switching in space will permit direct individual user-to-user addressability. Rather than duplicating these expensive and complex subsystems on individual satellites, they can be integrated on a large geostationary platform. Communications functions may then be plugged in to the power, antenna, and switching capabilities provided by the basic platform element.

Complexity inversion is a fundamental change in our approach to a space-ground system that has far-reaching potential. In the early days of the space program, every effort was made to keep the space segment of the system small and light; the corresponding ground segments had to be massive and complex. The reverse of this situation is now becoming feasible. Current trends in advanced electronics allow the space segment to be vastly more capable and complex, but still stay within reasonable launch cost and weight limitations, particularly considering the launch capabilities of the Space Shuttle.

By developing the ability to build extremely large structures in space and eventually by adding the presence of man to operate, service and update the system, we can have systems in the 1980s and 1990s that interface directly with users with useful, processed information. Such things as pocket telephones, direct-broadcast TV and global sensor monitoring become fasible, practical, and cost-effective.

Commercial communications applications of space is an area in which U.S. industry has clearly exceled. That position is being challenged by vigorous competition from Europe and Japan.

Our policy should be to stimulate commercial and industrial activities in space so as to develop new technologies, to encourage their exploitation for economic advancement, to develop new skills and competence in science and engineering and to assist U.S. industry in maintaining a position of leadership.

In addition to communications, other applications, principally weather, navigation and position location, and earth observation, should be reviewed for the proper role of government versus industry. It is now possible to achieve significant improvements in air traffic control and navigation by use of satellites. These services should be available to the private sector for agricultural, industrial, and energy operations, and to improve the effectiveness of aircraft and shipping operations and to enhance their safety.

Another major area of future space utilization is the use of the zero-gravity and high vacuum properties of space to study the physical properties of materials. This most likely will result in the development of radically new and economically valuable materials, and the development of new industrial processes to take advantage of this unique environment.

The space environment eliminates the disrupting influence induced by gravity in the formation of materials that prevent the achievement of theoretical strength/weight characteristics. The effect of gravity on industrial processes induces gravity-driven convection in molten materials, causing undesirable stirring and mixing. This disrupts the growth of crystals, the casting or solidification of alloys and composites and the separation of biological materials. Furthermore, the zero-gravity environment permits materials to be processed without the necessity to contain and confine liquids and molten materials within a solid container.

Beyond the new materials and processes developed in the unique environment of space, new fundamental discoveries may be made in the interfactions of materials and processes. Such knowledge allows the development of new industrial processes both in space and on earth, bringing out new material properties and products.

By the end of this decade, commercial space material processing may be a reality. By the end of the century, space processing installations in orbit will require higher power levels than currently available through the Space Shuttle and will spin off first a dedicated materials experiment carrier and then a manned, serviceable space factory in low earth orbit.

Other countries, particularly the Soviet Union, apparently encouraged by the results of space material processing experiments, are iincreasing their efforts.

During the next four years, the U.S. should decide if it wishes to pursue a manned mission to another planet or the moon. It is not clear what the benefits would be. A manned exploration beyond the moon would be undertaken for unique reasons of national policy. A national commitment of the Apollo type need not be made at this time; however, the outlines of a sensible program can be established and the important experimentnal work begun, if it is decided to make such a journey.

In the 1980's, the Shuttle and Spacelab will support laboratories in space, as well as most experiments aimed at understanding space as a medium. Other experiments will be carried by Shuttle-launched satellites using space propulsion stages. As space laboratories move from research to process development, they will require manned space bases either to house the laboratories or to support their assembly.

EXPLORATION AND SCIENCE

The U.S. has been the leader in the exploration of space. The goal of our future program should be to provide activities of scientific importance, leading to a familiarity with the entire solar system and exploitaton of that knowledge for our benefit.

The national program for planetary exploration and exploitation has been spectacularly successful. The funding requirements have been relatively modest. The U.S. planetary program has been a continual source of pride for Americans in the scientific and international areas. Unfortunately, lack of support by the executive branch of the government, the rising costs of missions and the lack of a coherent long-range plan with which Congress agrees have resulted in a slowing down of this program.

The Soviets have had an active program for many years. The Europeans have done a few missions and the Japanese are beginning to plan missions for the future. The Europeans, Soviets and the Japanese are planning a Halley's Comet intercept in 1986, while the U.S. does not plan such a mission.

Even though our program has been eminently successful, there is a great deal left to be done. The U.S. needs to establish a philosophical underpinning for its program to explore the solar system and develop a national consensus in support of it.

The country needs a thoughtful strategy for the systematic reconnaissance of the solar system. This program should cover the next 20 years with consistent pedictable executions. It should identify the priority and year in which missions are to be flown. It should meet the priority needs, both of national pride/competition aand scientific objectives. It should be funded at a predictable level agreed to by Congress and the Executive Branch. Within this level of funding and with the national objective specifiedd, its execution should be left to NASA.

NATIONAL SECURITY

Space programs are vital elements of our national defense posture. They enhance our ability to deter war. Space capabilities provide reconnaissance, surveillance, communications, weather, and navigation. They greatly augment our warning and intelligence capabilities. If we fail to deter war, space systems will improve our ability to deliver weapons, to assess damage and to manage military operations effectively.

We must be capable of conducting effective space operations during all conditions of conflict.

As the use of spce systems in military operations by the U.S. and the U.S.S.R. becomes more essential, they will become targets in wartime. Therefore, both the U.S. aand the U.S.S.R. may be expected to develop and refine anti-satellite (ASAT) capabilities for defensive purposes. Arms control agreements may contribute to stability by limiting the numbers and kinds of ASATs, but will probably not result in abolition of ASATs.

Reconnaissance of potential enemies is critical to our survival. Spacecraft are unique in their capability to provide this crucial intelligence information. Accordingly, we must continue to give overriding national priority to the satellite reconnaissance program.

To provide warning of attack and to permit more flexibility in our defense response options, we need an expanded and survivable surveillance warning system.

Communications are absolutely vital for effective military operations and communications via satellite systems and will be vital for protracted conflict on a global scale. The challenges to survivable, enduring space communications require that new technological opportunities be pursued.

Space has made a profound and lasting impact on weather forecasting. We need to give more emphasis to survivability of our weather satellite systems and we should examine ways of providing weather data to commanders during hostilities.

A profound evolution will occur in this decade through the implementation of the NavStar/Global Positioning System.

Our goals should be to exploit our highest available technology at the earliest practical opportunity; to lessen the vulnerability of our satellites to hostile attack or to unexpected equipment failures; and to extend the usefulness of our space systems for direct support of military operations.

The use of space systems for vital military operations imposes new requirements for their survivability, including satellites, ground stations, data links, and control centers. Such endurance can be achieved by either surviving attacks or by replacing space systems during conflict.

Our military commanders and our forces should employ, as a matter of routine, the range of satellite systems available for strategic and tactical operations. Greater familiarity with specific systems and their application is required and a doctrine and policy on the use of space must be promulgated.

Because of the need for U.S. military or paramilitary operations to be carried out in the most distant places around the globe and on short notice, a pre-positioned global system of tactical communications, observation, navigation, and positioning is needed and must be fully integrated into our forces.

THE NEXT STEPS

The immediate question in space program planning is what should be done beyond the programs already in development or operation. The Space Shuttle will yield immediate benefits and also open up new opportunities for the utilization of space. Payloads already planned provide global navigation, increase satellite communications capability, provide for manned on-orbit experiments and perform many other functions.

First, we need a vigorous research and development program. Here we should build on our strength and experience. NASA should carry out the basic research and development which they do so well, and agencies like the Air Force -- and others where appropriate -- can transform this R&D activity into the operational systems that we will need in the 21st Century. This same philosophy applies over a large range of disciplines.

We must also fully exploit the Space Shuttle. There will be much additional effort required if the Shuttle is to reach its potential and its promise. NASA, as a strong R&D agency, is fielding its first operational system, which had to be developed with severe financial constraints. Consequently -- and I believe under these conditions this is not a criticism of NASA -- it is almost certain that they have been forced to defer the solution of many problems into the operational era. Consequently, we will need a strong continuing product improvement program with the Shuttle; and I am not talking here about performance; that will take care of itself. I am talking about something we could call "operability"; that is, making the Shuttle more efficient and thus cheaper to use. This includes all of the many things that we have had to do in defense systems for many years; things which are not glamorous, but which are necessary. This includes the full range of logistics support; such things as improving maintainability and reliability, providing spare parts and minimizing the man-hours for Shuttle turn around. These and many other activities will be needed if the Shuttle is to become an efficient work-horse during this space era.

We must pursue advances in propulsion technology. The history of flight has always been such that propulsion break-throughs have proceeded any major new capability. The internal combustion engine preceded man's development of the first usable aircraft; the jet engine preceded the development of efficient and routine aviation operations. We have developed chemical rocket engines to take us into space. We are nearing the theoretical limits of chemical propulsion systems although I expect, for the foreseeable future, they will be the work-horse of the earth-to-orbit activity. We must pursue the technologies for nuclear and solar electric propulsion and perhaps some others that we have not yet even thought about. We must do the research and demonstrate the technology on any promising approach if we are to effectively exploit the space medium.

We must pursue energy producing technologies. Today's energy problems result primarily from the disruption of the distribution system rather than a lack of actual energy reserves. However, in the 21st Century we will begin to exhaust our reserves of fossil fuels. This may conjure up visions of large solar collectors beaming energy to earth, but that is a brute force approach to the problem which uses today's technology to project a solution for tomorrow's problems. I suspect we may be able to do much better. Here again we must investigate all the promising technologies.

Finally, we must get men into space and keep them there. This is the critical element in our ability to exploit the space medium for the benefit of all mankind.

In low earth orbit, the most useful major facility on the immediate horizon is the manned space base, or space operations center. This is the next major step required to support most of the longer term initiatives that are so important. Establishment of a permanent national presence in space is a natural outgrowth of the technological capability that the United States space program has developed to date. It has many intangible benefits, including national prestige, technology development and international cooperation. In addition, it is the direct implementation of many of the near-term space opportunities. It can have sensors to monitor space resources and environment with manned interpretive capability on board. It also can serve as the research facility for new made-in-space products, the development facility for new national defense technologies and a laboratory for scientific research.

A change in the philosophy of future spacecraft development can evolve. This new approach could include checkout of unmanned satellites on orbit before free flight, return of experimental hardware and refurbishment or replacement of expendables of unmanned spacecraft in orbit and assembly of structures. The manned space base may provide an opportunity for new commercial and industrial activities in space.

The programmatic requirements of establishing a manned space base as a possible focus for a future national space effort should be evaluated. Such a space base would have specific functions such as:

- Space construction facility
- Orbital transfer vehicle depot
- Assembly base for planetary vehicles
- Depot and in-space repair facility for satellites
- Earth observation platform

- Observatory (space, solar/terrestrial, international monitoring)
- Global weather, environment, and resource base
- Information processing center
- Space factory
- Research facility (medical, material processes).

Such a manned space base would be part of a wide variety of beneficial activities including defense, science and exploration and the industrialization of space. The space base program would represent U.S. national interest, but the benefits would also be increasingly international in scope and thus contribute to the U.S. role as a world leader.

One of the main justifications for both a manned facility in low earth orbit and new inter-orbit transportation capability is the benefit of deploying major installations in geostationary orbit. It is at this location that the benefits of physical size, high power, advanced electronics, and long, reliable life are most pronounced. Large, multibeam antennas on spacecraft or platforms at this location can communicate directly with thousands of inexpensive ground units whose antennas are only a few inches in size.

Small, unmanned communications satellites will continue to proliferate in geostationary orbit, but the quantum jump in benefits will depend on large platforms with associated major capability.

SPACE INFRASTRUCTURE

Our activities in space can best be conducted by modernization of our space infrastructure for launch vehicles and facilities, for command and control of satellite systems and for upper stages. For this near future, the U.S. space effort will depend on a mix of launch vehicles: Space Transportation Systems, both manned and possibly unmanned; expendable launch vehicles as a transition period; and perhaps launchers in survivable silos.

The future buildup in space will depend to a large part on the availability of economical transportation. The Space Shuttle and the orbital transfer vehicles are providing a new plateau of efficient space transportation. These vehicles will simplify system operations and enhance mission capability during the initial years of operation.

Many new programs, however, require further increases in capability. Evolutionary approaches, using the Space Shuttle as a base, offer a logical, low-cost and low-risk solution to these requirements. The Shuttle can evolve to support the requirements of new programs through growth and extension of its components.

Transportation beyond low earth orbit will require low-thrust solar electric propulsion to support the transport of small spacecraft to the outer planets, moons, and asteroids and to deliver platforms and large, delicate structures to geostationary orbit, and high-thrust vehicles, using chemical propulsion for transportation for cargo and personnel where quick transmit times are required.

A major question facing Shuttle operations is: Who should run it? Given that NASA has developed the Shuttle, it is not obvious that they are best equipped to operate it. Nor is it clear who else ought to. The Air Force certainly is a possibility, because they have the needed skills to perform continuing operations on an orderly basis. The counter-argument is that Air Force resources would have to be supplemented in order to meet the new and additional requirements of Space Shuttle operations. There would also be apprehension about DoD "taking over" our civilian space program. I do not envision that this would ever become a problem. Some have proposed to have, as the operator, a private or semi-private corporation, modeled after ComSat, Synthetic Fuels Corporation, or the DOE Laboratories. But this raises questions about future development of launch vehicles, responsibility for manned flight and military control of military operations; this last point is particularly important since the Air Force must have direct control of those military operations which are so essential to defending this country.

It is important to reexamine the existing management of our entire space program and reacquire the ability to complete programs rapidly. Serious consideration should be given to management arrangements which are responsive to urgent needs and provide effective and rapid action.

SUMMARY AND CONCLUSIONS

The advent of the Space Shuttle, albeit late and often criticized, has opened a new era in space opportunities. It allows us to use space to enhance our economy, to contribute to our expansion of knowledge and enhance our security. It allows us to stand tall and be proud of our nation's achievements.

Our future space policy should emphasize three main elements:

- The private sector should be provided greater opportunities and incentives to support an increasing share of our space effort and to maintain our competition edge.
- Our leadership in space exploration should be supported and new opportunities exploited for science and national prestige.

- It should be recognized that space resources are vital elements of our national defense posture and a doctrine on the use of space by military commanders must be promulgated.

These space policy considerations should be accompanied by programmatic decisions emphasizing:

- The reaffirmation of an orderly space infrastructure, including operations of the Space Shuttle, orbital transfer vehicles and command and control architecture.
- The development of a low earth orbit manned space base to conduct commercial, scientific and military support functions.
- The establishment of an orderly long range space exploration program.
- The development of a space architecture for the employment of military systems as an essential element of maintaining our national freedom.

With a clear enunciation of the above policies and programmatic goals we can indeed reap the rewards that our past investments in space technology have brought within our grasp.

I would like to wrap up my thoughts, and perhaps inject a personal view. We are in a time of serious economic problems and basic research, with its long-term payoff, is always an easy area to cut. I remember quite vividly how, during my tenure as chief of Air Force research and development, we would have problems maintaining continuity of our R&D efforts; these apparent near term savings would invariably lead to much higher costs -- and reduced operational capability -- downstream. We must avoid the temptation to mortgage our nation's future in this way.

I have worked as an astronaut and as an Air Force officer. I have worked in space and I have seen the Soviet capability there first-hand. I am concerned about the Soviet advantage in manned space flight; they have a continuing commitment to an expanded, manned military space flight program and I believe that we must effectively exploit the space medium if we are to remain a free country into the 21st Century. We have leap-frogged the Soviets with the Space Shuttle; we are far ahead in electronics and in space propulsion technologies. All of these things give us a significant edge in future manned space flight.

I believe it is absolutely essential that we remember that today's research and development provides tomorrow's edge -- both in commerce and in defense. We need to keep a strong civil NASA research and developmment program. Other agencies, like the Air Force and American industry, can exploit that research and development to meet our country's needs as we move from the present time through the first 30 years of the 21st Century.

Mr. Chairman, this commpletes my formal statement, I would be happy to answer questions from you or the members of your Committee. Thank you.

Mr. FLIPPO. General, thank you very much for that statement. I think you have put your finger on what we are trying to do in these hearings, trying to find ways to communicate the importance of the scientific effort and the space program to the American people and to our colleagues. You contributed that today by your presence here and I appreciate it very much.

I am very interested in this. You make an interesting observation that:

> We must re-examine the existing management of our entire space program. We should include both military and civil space activities with emphasis on operation of the shuttle. Serious consideration should be given to management arrangements which are responsive to urgent needs and provide effective and rapid action.

I believe in trying to define the objectives of the space program, and there are many, but among those are defense, the prestige factor, and people have related that to foreign affairs, the State Department perhaps. So we have defense, DOD, the State Department perhaps in the prestige arena, pursuit of knowledge for the academic community, and I believe we have economic benefit. Are you suggesting that maybe we need some kind of super organization to coordinate the activities of, say, NASA and the Department of Defense and perhaps Commerce and the State Department? Does the left hand know what the right hand is doing?

Example: Upper stage development, perhaps. Should the Nation develop, should NASA develop an upper stage solely for NASA's use or perhaps should someone coordinate defense needs with space needs and commerce needs and what have you?

General STAFFORD. Well, you would hope it would be a coordinated effort. In my own views, Mr. Chairman, I think it would be appropriate for the National Security Council to review our space efforts and where we are going. I mentioned that NASA does an outstanding job in the research and development, and that they should be encouraged to continue to reach rapid solutions to problems, but now you are faced with a problem.

We built up a tremendous organization during the Apollo program and now Apollo is gone. Every organization is faced with its own budget line items, its own TOA authority, and a major effort to take the Shuttle operational under NASA is going to inhibit certain other programs just by the budget level you put on top of whether it is deep space research, aeronautics, things of this nature. So at this time it would be, I would think, appropriate to review who should really operate the Space Shuttle.

There are two subsets to this aspect, Mr. Chairman. There is the launch operation and then there is on-orbit operation, but NASA should be able to have the flexibility and the push and the freedom to really continue research and development. This is what they do best.

I flew two missions in the Gemini program and two missions in the Apollo program. Those were not operational missions. They were research and development missions with specific objectives defined. To me it is logical for a review to be performed by the National Security Council, or perhaps, a committee review from the Congress in conjunction with the NSC review to determine where do we go in the future. We are really at a juncture, because we are starting to have some operational systems developing instead of the typical R. & D. space activities of the past.

Mr. FLIPPO. General, on page 8 you say, "We must avoid the temptation to mortgage our Nation's future." Would you have any specific suggestions as to how we can better explain the space program and its needs and how it relates to the Nation's future to those who pay for the program, the taxpayers?

General STAFFORD. Well, this is a very difficult task, Mr. Chairman, as I pointed out. Oftentimes the person in the street, in fact even people in certain forms of business, are not aware of what research and development does as far as the productivity and the payoffs. It is very hard to explain to them that the money invested now is going to have a great payoff 10, 15, 20, 25 years from now. If you look at the jet engine and all of the research that went there, including some of the aluminum alloys, those could very easily have been cut out early in the development cycles. It is a tough problem. I know that when I ran Air Force research and development, we would have budget exercises, and one of the first things you could cut is research and development. I guess being an old country boy, I vividly recall the saying that when you are up to your knees in alligators it is very hard to remember that your basic objective was to drain the swamp when you arrived there.

Mr. FLIPPO. That is true. Yet we had Dr. Long testify how he was using space technology in the medical area for the relief of pain, and using other measuring devices in neurological surgery. He told us that the adaptation of that technology was almost accidental. There was no driving force, no organized method of getting that information out.

General STAFFORD. Mr. Chairman, I think it would be appropriate for the committee to emphasize to Mr. Beggs and to Dr. Mark that this is the time it has got to be done, particularly for NASA, to really get across the needed communications to the American public explaining what we are doing. It has been, as I said, one of the failures that I have seen in the past—NASA—and also somewhat in DOD.

Mr. FLIPPO. Mr. Brown.

Mr. BROWN. Mr. Stafford, there are a couple of things in your testimony that I want to touch on, just because of the lack of time more than anything else. You have projected a 50-year scenario, I guess you would call it, and it intrigues me because I have been focusing on the needs to do a little better job of forecasting and strategic planning in many different technological areas. I wouldn't call your scenario exactly a strategic plan, but it has a lot of the elements of it there.

I would like to ask you to comment on whether or not there would be some value from an even rudimentary effort to flesh out, say, a 50-year program, which isn't too difficult from the technology standpoint. The difficulty is translating that into impacts on society in many different ways.

Do you think there would be some value in doing the kind of thing that you have done in a rudimentary fashion on a slightly more systematic basis, and subjecting that to public or political discussion as a means of focusing on some of the policy decisions that need to be made?

General STAFFORD. Mr. Brown, yes, there could be a value to it, and I would say a positive value. I would think that as a starting point, though, it could be done by systematic analysis in NASA, the National Security Council, even a subcommittee in the Congress, before it was put to the public, because oftentimes when a question is put to the public without the proper things——

Mr. BROWN. I agree with that. Let me just ask you from the standpoint of your experience in the military, do you do this kind of thing in the military? Do you look down the road 20, 30, 50 years at possible changes in the strategic balance resulting from developments that can occur from various things?

General STAFFORD. Yes, sir, we do, and from that you work forward, then working back as to what is a potential aggressor threat, and from that it works back into requirements and then from there into your immediate future, which is your 5-year defense plan. To me that would have a certain validity to look forward, and then bring it back, as to what would be the priorities of the budget.

Mr. BROWN. I won't lead you any further along this path. I happen to agree very much. Looking at the element of propulsion system which you indicate correctly is generally the pacing element in developments of this sort, do you have any concept of what might be the follow-on to our chemical propulsion rocket systems?

General **Stafford**. There can be a lot of areas there. Of course, you know the deep space propulsion, you are looking at advance ion propulsion.

Mr. **Brown**. I am looking at launch propulsion.

General **Stafford**. As far as launch propulsion, the one area that could be a great potential is metallic hydrogen. This would be very difficult to obtain, but the specific impulse is fantastic.

Mr. **Brown**. Metallic hydrogen?

General **Stafford**. Right.

Mr. **Brown**. Is that cryogenic?

General **Stafford**. It is beyond it, It is the superdensity and beyond that. We are really into cryogenics now, we have that on the Shuttle, but the superdensity and also its application down the road for weapons systems could be fantastic. The payload capability and the throw weights that you could develop from this is great but that is way down the road in the future.

Mr. **Brown**. Some of the scientific writers have envisioned something they call a mass thruster, which is basically an electromagnetic-driven system. Is that something that can be looked at from a practical standpoint? In other words, it would be like taking one of these French trains and pointing it up in the air and shooting it off.

General **Stafford**. Right now I don't think I would be in a position to give a positive answer on that item specifically, Mr. Brown. But again, with the emphasis as far as just pure policy that the committee could put forth to NASA requiring them to examine the priorities they envision for advanced propulsion. This effort should be able to be identified before too long a time.

Mr. **Brown**. It would have a value that a good part of the system could be kept on Earth and the vehicle itself could be relatively light?

General **Stafford**. Right.

Mr. **Brown**. I want you to explore that a little bit more and come up with some good ideas on it.

General **Stafford**. All right. What I would like to do, sir, in length of time, is just to submit some ideas for the record, if I could.

Mr. **Brown**. Yes, you don't have to do it right this minute. Thank you, Mr. Chairman.

[The information follows:]

PROPULSION TECHNOLOGY

I would like to cover this in several segments. First, dealing with earth-to-orbit and then with orbit-to-orbit propulsion. As I said before, we are nearing the limits of chemical propulsion systems. However, these will remain the basis for our earth orbit activity for many years to come and significant improvements in these areas may still be possible.

By the way, while my discussions focus on performance we also should not forget that we need to be concerned with reliability and reuseability and things of that nature which result in economical operation.

We should strive to obtain the highest reasonable levels of specific impulse propulsion; for example, every second of specific impulse increase on the Shuttle represents 1,000 additional pounds into in orbit, purely through efficiency improvements. There is also some potential that should be explored in other fuels besides liquid oxygen and liquid hydrogen. One of the major limitations is the low density and the resulting very large propellant tankage, required to contain the liquid hydrogen. Some of the hydrocarbon fuels, because of their greater density, can result in a space vehicle with an improvement in "mass fraction," that is we have less vehicle dead weight to carry around and that might prove to be advantageous in terms of total payload weight into orbit. Liquid oxygen and methane is one combination with that potential. Now over the longer term things such as the metalic hydrogen I mentioned earlier might have possibilities. Further, it makes some sense to look seriously into "rail guns", or the electromagnetic accelerator that Mr. Brown mentioned earlier. It is conceiveable that an extremely large device of this type may have value for earth-to-orbit applications. Clearly the accelerations would be excessive for manned flight, but this might be quite useful for delivering construction materials or propellants into low earth orbit. These technologies deserve some further investigation, and there may be others as well.

Once in orbit, if we are going to operate effectively with space stations and the like, it will be necessary to move freely between earth orbits and ultimately beyond earth out to the planets--and perhaps even beyond--with manned vehicles much larger than anything we have operated to date. A number of technologies appear promising in this area. In the near term, electric propulsion using mercury ion bombardment thrusters is already feasible. These provide very low thrust measured in milli-pounds, and so transit times are relatively long; but for many missions this is quite acceptable. A slightly different approach using inert gas ions, can potentially provide greater performance. Significantly higher performance might be available if the solar electric power source was replaced by nuclear power sources; this becomes even more attractive when we talk about magnetoplasma-dynamic, or MPD, thrusters which would require mega-watt power levels. All of these systems have much much higher specific impulse--perhaps 10 or more times that of chemical propulsion--and thus make very efficient use of their propellants. That enables relatively large accelerations although over a longer time, with relatively smaller propellant mass than with the chemical systems. This represents the kind of thing we need to do in orbit. Now, when men are involved, we have to be concerned about transit times and so there is some middle ground to be found in terms of combination of thrust and specific impulse. Consequently, for the orbit-toorbit regime, systems of this kind deserve continued attention.

Now let me go briefly beyond even beyond that. The real break-throughs don't come through the things we know about today which we can explain well enough to at least define the phenomena. The real break throughs, the things meaningful in 50 or a 100 years, are probably still in the back of some researcher's mind, a physicist or a mathematician in one of our laboratories or universities. We need to continue this pure research. Just as an example, we know that today there exist particles in the atomic structure that could be called "anti-matter" and it is not terribly far-fetched to conceive that we might one day be able to make the translation from knowing those kinds of particles exist to building a matter/anti-matter propulsion system like we see in Star Trek. But if those breakthroughs--or others that we can't even think about--are ever to happen, it is going to be necessary to pursue the basic research that has the long term payoff.

So in conclusion, I would say there is a broad regime of areas that this Committee, in conjunction with NASA, should pursue and which will have significant potential for long-term benefits.

Mr. **Flippo**. Thank you, Mr. Brown. Mr. Winn.

Mr. **Winn**. Thank you, Mr. Chairman.

Tom, I welcome you to the committee again. I am always interested in what you have to say. I would like to point out that many of the people on the committee and some in the audience don't know that he is a good photographer; he also has good sense. He had many opportunities to run for public office and he chose not to.

There are some of us, not just because of the delay announced this morning on the Shuttle, who think maybe we have bitten off more than we can chew with the Shuttle. From an economic point it is obviously extremely expensive. It has semiproven itself. It is an extremely complicated vehicle, with many, many things that could go wrong, and obviously they are. They did 2 weeks ago. They did again yesterday. They will again tomorrow or the next day or at some time.

We are always sharing, as we well know, the Shuttle facilities and capabilities with the military, which is probably one reason that we can help get it financed, that we can help get it approved by Congress, because of the joint relationship there, but there is a military use, obviously, that I mentioned. There is a civilian use, obviously, where the scientific community comes into play, and I am wondering, and I have wondered the 14 years I have been on this committee, how we can do a better job of selling the public.

I have thought for years, like many others, that we have not done a very good job, and it is easy for us to sit here and criticize NASA. What if we turned this thing around, particularly in view of the attitudes of the young people of this Nation, which is questionable whether they really would support the military aspects.

If we could develop a program, and some programs, which would show them that the civilian aspects have great peaceful potential, and maybe get the younger people on our side for future shuttles or whatever the next step or stage of the program might be. I don't think we have really approached it from that direction. It is another possibility. It may be a little bit of a remote possibility but there are, and could be in the future, many more experiments aboard the pallets that would show the young people here and the young people around the world, if we could include them in some way, maybe through the universities, but not necessarily through the universities, because the scientific community seems to want to take those over, and the developing nations, Third World countries, that we are good, that we are No. 1 in space, but we are going to share a lot of these things with you.

I have given that thing some thought. I don't know how to put it together. It's like the question George Brown asked you. It doesn't need an answer right now,. but do you think it has got any possibilities of a third approach other than a civilian approach and a military approach which we are now on, to go into a program by either the United States alone or through the United Nations?

General **Stafford**. Mr. Winn, I think that it certainly has merit. In the speeches I make around the country, I find a great enthusiasm among the younger people for the space program. It is kind of a new frontier. It is still exciting to them. The way to include them and to generate, some positive information, some positive publicity, and really some positive results, would be to have experiments where you identify a group of young people that could participate in the experiments. I would think at least today NASA would be the best place to start with.

Mr. WINN. I am not looking for any new bureaucracy, believe me.

General STAFFORD. Yes, right, but I think due to the enthusiasm I have seen, in my travels around the United States and really around the world, that this could be a positive approach, sir.

Mr. WINN. You know we had during Vietnam a group called the peaceniks. I don't know exactly what that meant, but the name caught on. They also wrote a lot of vociferous letters to Members of Congress too, but I think that they had a point, and now they are growing up and have grown up and are getting married and raising families and trying to buy houses, cars, and all the things that we have all gone through.

I am trying to figure out those people who are paying taxes, and will be paying taxes, if we could get support fairly early from them, because they feel that their peacenik beliefs in the Vietnam days now could be coming to fruition through the space program, and it is going to be a little hard for them, because they know that there are military experiments aboard at the same time. I don't know if we could put all three subject matters into bed at the same time.

General STAFFORD. When you review the traffic model for the missions of the Space Shuttle, Mr. Winn, there are a whole series, as you know, for civilian purposes, that could accommodate this. I am not talking sophisticated experiments. I am talking small experiments, particularly with the large Shuttle payload bay and the weight capability we have, it can certainly be feasible. It could have the potential of a positive aspect.

Mr. WINN. Particularly when we get an operational system?

General STAFFORD. Right.

Mr. WINN. I fully expect that there will be some big changes, once the Shuttle becomes fully operational, other than what they have signed up at the present time. I am looking for some new interests, some new, say, special interests in the form of peacekeeping that could sign aboard with some type of experiments that they would feel a part of, and that would be beneficial to people around the world. I go back to our communications that Dr. Baker mentioned, our educational, medical communications system with India and Alaska. That was a real great thing.

I think most of the members who were on the committee at that time saw the true benefits and saw our communications with people in India and people in remote parts of Alaska that needed medical advice or educational help. Then, typically, we researched it, developed it, and moved it away and left them without the system, after we showed them what we could do.

General STAFFORD. I guess you would say this is the bottom line, sir, and this is what I have said in many speeches. One of the real reasons for going out into space is to come back and solve problems right here on Earth. That to me is the bottom line, Mr. Winn, to solve problems here on the Earth using space, and I think we can do a very effective job of making a better world to live in. Using that as a criteria to show these young people that by using space as a media to have these experiments, and how it does affect and solve our problems here on Earth would be a very positive effort.

Mr. **Winn**. Thank you, Tom. Thank you, Mr. Chairman.

Mr. **Flippo**. Mr. McGrath.

Mr. **McGrath**. Thank you, Mr. Chairman.

General, it is a pleasure to see you here again. I am going to make a statement and then perhaps you can react to it. I am new to this subcommittee, and I have been, in that newness, through Bob Frosch, Alan Lovelace, now Jim Beggs, and perhaps some more. I was interested in your remark regarding continuity and PR. I fully recognize, without denigrating any of those great scientists at all, the need to promote the space program.

I have wondered often why this administration or the last administration and the administration before that did not enlist people like yourself, other than financial considerations, I am sure, why they didn't enlist people like yourself. You know, one thing this country needs, and the astronauts have provided, is heroes. You being in the Apollo mission, the Gemini mission, the Apollo-Soyuz mission, and you or your colleagues, probably better than anybody else could promote the program, the NASA program.

I am just wondering why—you don't have to answer this, but why the administration just hasn't seen the light, I believe. They want to promote and continue an ongoing space program for civilian use and also military use but they don't use their best promotion, the heroes of the past two decades. I don't know whether you want to react to that.

I was also interested in, in light of the operational problems that we seemingly have on the Shuttle at this point, and the fact that you say it is probably going to take 10 years, if the past is prologue, we had a 10-year hiatus before we had a success in the space program, if we are going to wait 10 years to become operational, fully operational in the program, in light of what Dr. Baker said of needing every so often a success, where is that going to leave our space program, if we are going to spend the next 10 years becoming operational in the Shuttle?

General **Stafford**. In becoming fully operational, Mr. McGrath, I did not mean to imply that we were not making effective use of the Shuttle. But fully operational, we talk of minimum turnaround times on the vehicle and to have the ready adaptation of those payloads without severe constraints on the payload. We will get into an operational status, a limited operational status in 1983 or 1984, but it will be a limited operational status.

It will become fully operational during this decade, and will we finally start to work, with men working in space nearly on a continual basis. We are going to find more and more aspects that we haven't even thought of today. That has been the history of what we did in both the Gemini program and the Apollo program. The final Gemini missions compared to the first, the final Apollo missions compared to the first and even the last Skylab mission. They were far greater than what we envisioned when we started with the programs.

Mr. **McGrath**. You mentioned your expertise as far as knowledge of the Soviet program and its commitments to space. I am wondering how we can reconcile the conditions in the Soviet Union today, the human conditions in the Soviet Union today versus the human conditions here vis-a-vis the space program, given the fact that the Soviet Union still has bread lines, the highest alcoholism rate in the world and whatsoever, and that seemingly being a reaction to overproduction in defense and perhaps an overstimulation of the space program. Can you react to that?

General STAFFORD. With the problems that any society has, you still have the governing forces putting forth certain priorities and programs. So in spite of some of the economic and other problems that you have mentioned, they have still seen fit as one of their priorities to have a strong, vigorous space program, and that is both the civilian and military programs.

Mr. MCGRATH. I have no further questions.

Mr. FLIPPO. Mr. Lowery.

Mr. LOWERY. Thank you, Mr. Chairman.

General, welcome to the committee. I am a newcomer and I have enjoyed your testimony very much, in perspective. In your testimony on page 2 you talk about significant pressure on the Shuttle, its capability. I want to follow up on the questions that my colleagues asked. That pressure, coupled with our budget pressures that Mr. Winn pointed out, how do you see this in terms of the need for greater capability, realizing that the existing system we have is extremely expensive?

General STAFFORD. This enters into what I call the product improvement program, Mr. Lowery. The basic investment, a huge investment that has already been made in the Shuttle. What will follow on as far as the product improvement program, unless there is some major flaw that we cannot see now, will be somewhat minor in expense compared to what we have had to appropriate in the past.

I would envision it to cost just a fraction, but I wanted to outline this as an item that should be one of the priorities when you people consider the budgets. We have spent a lot of time and a lot of effort, and have done a lot of compromising getting the system. But to make it have that final bit of effectiveness is going to take a little bit more money, and that should have a priority to make it effective.

Mr. LOWERY. Do you have any idea how much more money we are looking at?

General STAFFORD. No, sir, I would not want to make an estimate at this time. In fact, I don't know that anybody can make an estimate, because it is just the same when you develop an airplane, as you go down through the research and development, the flight test program of an airplane, and you put it into operation. I remember very well when the first 747 started flying, they had extreme difficulty with the engines. The high bypass ratio fan at sea level tended to get out of a complete circle and became oblong. That wasn't forecast. This is one of the many problems you run into whether it is an aircraft or a spacecraft.

Mr. LOWERY. Would you anticipate a second-generation Shuttle, and when would you see that as being phased in?

General STAFFORD. I would envision, say, really a modification like a series with this Shuttle. It would be a long time before we would exceed the requirements of this Shuttle. I would say then it should last up into the 21st century. What you will see is modifications just like you have a modification programs with aircraft. To me, the Shuttle we have designed now should last us up to the year 2000 plus.

Mr. LOWERY. Do you see a time when the Air Force will be procuring their own Shuttle systems?

General STAFFORD. That would have to be an administration decision. I agree with the previous concept where you have NASA develop the major manned space vehicles, and they integrate the requirements of the military into the vehicles. I think this is the way it should be in the future.

There is really a good reason for that, particularly as I saw it when I was over on the military side, when the budget pressure gets tight, and the military prioritizes more of the operational items.

If you have to make tradeoffs between putting research and development money into a Shuttle or modifications for the F-15 you are probably going to mod the F-15, so I think it is good that NASA continues on as the developer of these space vehicles. But as to whether the military would buy it, it still comes out of the administration's pocket, whatever the administration is. NASA is procuring the shuttles and I think that is fine.

Mr. LOWERY. We have heard a great deal today and in past testimony about the coordination of information and knowledge. As someone said today, the left hand doesn't know what the right hand is doing. I think it would be more appropriate that the administration on the right doesn't know what the far right is doing. You have seen it from both sides, both from NASA and from the Air Force.

Is there not a better way that we can share the R. & D. results? It seems that there is a great deal of redundancy in various scientific pockets around the country, and that we are not getting the most bang for our buck. Do you have some suggestions as to how we can further improve that?

General STAFFORD. I'm sure we are far from perfect, but I really think we do pretty well overall in this area. What I would like to do is give this some more thought and to submit for the record and specific recommendations which come to mind to reduce redundancy in R. & D. I would like to state, though, that we are now in this transition period between what is operations and what is research and development, and this is a near-term problem that we have got to solve, and perhaps particularly on launch vehicles. NASA may want the Air Force to take care of just the launching where NASA would have the operation of all the civilian vehicles in orbit, but there is only so much money in the budget to go around, and this is a near-term problem.

In my viewpoint, the National Security Council should again review all the missions and roles.

Mr. LOWERY. A quick question. Would you anticipate saving money as well as manpower through some of your suggestions and recommendations?

General STAFFORD. Yes, sir.

Mr. Lowery. In addition to getting much better information. Where do you anticipate the Soviet Union is in the development of a Shuttle?

General Stafford. The Soviet Union traditionally in both aircraft and spacecraft have taken an evolutionary role vis-a-vis a revolutionary role. I am sure that they are conducting basic research and development as far as high-energy engines like we have on the Shuttle and also investigating the tiles, thermal protection system, and the flight control system. However, they would approach it, in my viewpoint, very gradually, because the Soyuz booster that they are flying now, flies off the same launch pad that launched their first satellite and the same one that Yuri Gagarin launched from.

It is just a modification of their basic booster. While theirs is an evolutionary program, it works for them.

Mr. Lowery. We go out for the spectacular?

General Stafford. We do it revolutionary.

Mr. Lowery. You have seen and studied the Soviet Union and their entire space program, and I appreciate your comments that they have a more of a long-range goal and a consistency, more so than do we. What do you see as that long-range goal?

General Stafford. The immediate long-range goal, which they are starting to achieve, is to have men continually in orbit. I am talking about their manned program to start with, men in orbit on a continual basis, and an improvement of their Salut space station. We are talking of an improved Salut space station that would have more than the basic two men there for long periods of time.

Mr. Lowery. Permanent men in space?

General Stafford. Yes, sir.

Mr. Lowery. For military purposes?

General Stafford. Their purposes would be both for civilian purposes and military purposes. The way they have it over there, they don't have to worry too much about the differentiation between the two programs.

Mr. Lowery. What do you anticipate their expanded capability will be with permanent men in space?

General Stafford. In the near term they would carry out a series of experiments. After that, say, into the nineties you would have a more operational type of space station like the national command and control center. This could be put up there very easily, just like one of our future ideas for the military operations. We can have a national command and control center in space. We certainly have the communications, and all you really need is the orbital models and the access to go back and forth to them.

Mr. Lowery. Did you find the Soviets have a different attitude than we do both in terms of how they approach their engineering as well as their sciences?

General Stafford. Could you repeat that again?

Mr. Lowery. Do the Soviets have a different attitude than we? You mentioned an evolutionary approach as opposed to revolutionary. They are more consistent in their long-range goals. But did you likewise find that their attitudes toward engineering and toward the sciences are different than ours?

General STAFFORD. No, sir, I do not think their attitude toward science and engineering is any different than ours. They have a certain advantage on their policy as far as the long-term goal, but our advantages, that I have observed, are in the freedom of communications and the synergistic effect it has. The availability of a person to make a giant step forward, and if he fails without too much criticism.

Mr. LOWERY. More creativity?

General STAFFORD. Yes, we have more creativity.

Mr. LOWERY. Thank you, sir. Thank you, Mr. Chairman.

Mr. McGRATH. General, just one more question. With the development at Vandenberg, the Western launch facility, with the development of the somewhat redundant control center being at least thought of in Colorado, construction of that by the Air Force, given the different goals for both the Department of Defense and NASA, sometimes the consternation that exists between those agencies, do you see in either the near or long term a separate Shuttle fleet?

General STAFFORD. There could be a separate Shuttle fleet, but this would have to be examined. There could be two reasons for it, sir. One would be just purely payload, due to Vandenberg, and the heavy payloads that the Air Force is required to provide for the DOD in polar orbit. Only the latter two or three Shuttles will have that payload capability.

The first two Shuttles will not have the extra payload capability, so from that viewpoint even though the others could come back and fly out of the Cape, you would like to keep all the interoperability possible. The other reason would be secure communications. However, at this time I think it would be easier to have two dedicated Shuttles stationed at Vandenberg, if the mission model were there. Two would be stationed at the Cape with the availability to move them back and forth.

Mr. McGRATH. Just given the fact that seemingly there are large expenditures being made by the Air Force in terms of what I consider to be, could be construed to be a redundant control area in Colorado, doesn't that lead you to believe that this may be a possibility, rather than any payload factor? In other words, all of that, isn't there a need to have a civilian fleet and a military fleet?

General STAFFORD. As far as just a pure booster at this time, the answer could be yes and no. As far as the control center, now that is a completely separate item, since the original satellite control facility is near the San Andreas fault and there are some other problems that we cannot discuss in detail in open hearing. So there was a justification for that backup of the satellite control facility.

As far as just pure Air Force and NASA Shuttles, one for each, you could make the case to justify them, but, again, to me they will still always be used interoperably. Let me give you an example, sir.

For on the Gemini program, there was the Air Force Titan ballistic missile that we modified to accept the Gemini spacecraft. The Air Force conducted all of the launching but NASA had control of the mission. The same way the Voyager program, which has been so successful, using the Air Force Titan 3 boster. The Air Force launched the booster and NASA had control of the mission. What I have found in the past, is even though there has been some minor friction, the overall interoperability between NASA and the Air Force has been very fine.

Mr. McGRATH. Thank you, sir.

Mr. FLIPPO. General, thank you very much for your testimony. You have been very helpful to us.

You mentioned elimination of peaks and valleys in funding. Over the last several years there are those who would like to eliminate the peaks and leave the valleys, and that is what we are trying to avoid. Thank you very much for your testimony.

General STAFFORD. Thank you.

Mr. FLIPPO. Our next witness, Mr. Jack Young, is a guy who makes things work. He is presently a professor in the Center for Technology Advancement at American University, but before that he had a very long and distinguished career at NASA, Department of Engineering, OMB, and HEW. Of course, one thing we need to understand is how we can inject future space goals and long-range plans into the decisionmaking processes of the Federal Government. Dr. Young should be able, and I am sure he will, to help us with that chore.

Thank you very much. Will you proceed as you feel appropriate.

[A biographical sketch of Mr. Young follows:]

BIOGRAPHICAL SKETCH OF

JOHN D. YOUNG

Professor of Public Management
The American University
Center for Technology
and Administration

NAME: John D. Young

AGE: 62

PLACE OF BIRTH: Cortland, New York

EDUCATION:
Colgate University, 1941, A.B., Social Science
Syracuse University, 1943, M.S., Public Administration
American University, 1974, Ph.D., Public Administration

WORK EXPERIENCE:

Sept. 1979 to Present - Professor of Public Management, The American University, Center for Technology and Administration

Nov. 1977 - Feb. 1979 - Deputy Undersecretary, U. S. Department of Energy

Oct. 1971 - 1977 - Assistant Secretary, Comptroller Department of Health, Education and Welfare

1966 - 1973 - U. S. Office of Management and Budget (formerly Bureau of the Budget)

(1) Deputy Associate Director, Energy and Science Division

(2) Director and Chief, Economics, Science, and Technology Division

1960 - 1966 - National Aeronautics and Space Administration

(1) Assistant Administrator for Administration

(2) Deputy Director for Administration

(3) Director, Management Analysis Division

1954 - 1960 - McKinsey and Co., Inc. (Management Consulting)

(1) Studies of Federal, State and Local Government Operations

McKinsey and Co. (continued)

(2) Studies of Private Industry Operations

1949 - 1954 - Office of Defense Mobilization

(1) Executive Officer

(2) Executive Secretary

Special Assistant to Administrator, Federal
Civil Defense Administration

1942 - 1945 - U. S. Marine Corps

PFC to Captain in U. S. Marine Corps Reserve.

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STATEMENT OF JOHN W. YOUNG, CENTER FOR TECHNOLOGY AND ADMINISTRATION, AMERICAN UNIVERSITY (FORMERLY WITH OMB)

Mr. YOUNG. Mr. Chairman and members of the committee, this is indeed a pleasure. Professors, I have learned, do not make things happen. I doubt if bureaucrats do anymore.

I am a little upset with my testimony. It would not have been approved by OMB if I had been down there. I am not quite familiar with the kinds of privileges I can take these days, but I intend to take some.

The word "pragmatic" bothers me but I think I can fit myself into it because it says in the dictionary, busy in an objectionable way, officious mentally, stiff in one's opinion, opinionated, and dogmatic.

I will do my best. My testimony says don't worry about the future because the base from the future that you would go from is disappearing. The complex of organization were fragilely built to do the job we have done, made up of government agencies, industry, and particularly universities when it came to scientific research. That complex, fragilely put together and sustained, beginning in 1958, is now slowly being winnowed away. No longer is there sufficient program to maintain as many facilities and professionals as you have. That is our issue.

I think you can go along with General Stafford. He has laid out a very credible program for the next 50 years, but unless you maintain today the base that you have built, you will have difficulty sustaining any program efficiently and effectively in the future. There are already indications in failures such as SeaSat and the sliprings, what happened yesterday at the Cape and will continue to happen, these programs are now underfunded and the base is now threatened. This is the gist of my remarks. I am open for questions.

[The prepared statement of Mr. Young follows:]

TESTIMONY OF JOHN D. YOUNG
BEFORE
SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS

September 23, 1981

Mr. Chairman and Members of the Committee, it is a pleasure to appear before the Committee to discuss topics related to the future of the national space program and the capabilities that program creates for other elements and sectors of our national well being.

As requested by the Committee these remarks will be brief. They will not focus on the planning of future space programs; they will attempt no technological forecasts; they will not cover any thoughts on past or expected economic returns, or justifications, for space programs or individual projects. They will focus on selected aspects of today's situation that threaten--or certainly becloud--the planning and effective execution of future space programs regardless of what the specific programs may or may not be.

Before covering the specific topics let me set forth two assumptions that underlie and create a framework for discussion of the topics that follow:

1. To continue to pursue the search for a coherent national space policy in these kind of times is probably going to be most frustrating for the involved participants. This is true even though a recent survey conducted by the National Science

Foundation indicated:

> Overall, those interviewed favored increased exploration of space by 2 to 1, although those in the youngest category were less enamoured of space exploration than those of the sputnik generation.[1]

Very few political leaders, regardless of party, or other convictions will want to clearly stake themselves out for a specific future space program that costs much more than the current program -- if that much. There is no effective constituency for such a future program when you come face-to-face with such trade-offs as changes in Social Security, further reductions in student assistance for middle class families, and similar federal programs. The general tendency of the American electorate is to support many things such as the space program until it comes to trade-offs where the individual sees his or her own self-interest at risk.

2. A basic concept of any effective planning process is simply this: "You've got to start from where you are if you want to get to where you want to get at some future time."

1/ "Public Backing Science Worries About Change," The Washington Post, Friday, August 21, 1981, page A3.

It is this second assumption on which I wish to focus my remaining remarks. My contention and concern is that our current base for today's space program -- to say nothing of tomorrow's -- is slowly, surely and perceptively being winnowed away. This is probably more unconsciously than consciously taking place. The recent revised budget submitted by President Reagan on March 10, 1981 stated:

> The revised budget proposes to eliminate or defer all 1981 and 1982 new program initiatives in space transportation, space science, space and terrestrial applications and areonautics R and D.[1]

The budget revision text then goes on to specify reductions in ongoing programs.

These kinds of actions cannot continue much longer and still expect the U. S. space and aeronautical base to even carry on effectively and efficiently the current or future space programs. This base is composed of such critical elements as concepts of what should be done in-house and what should be done by contractors and how contract work should be managed. It is made up of a delicate complex of relationships among Federal Government agencies, primarily NASA, industry and universities that have learned how to work effectively together by trial and error and successfully accomplishing what not so long ago would have been considered impossible.

This complex of concepts, organizations, facilities and most importantly thousands of professional staff cannot be

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1/ Additional Details on Budget Savings, Executive Office of the President, Office of Management and Budget, April 1981, page 302.

"stockpiled" as certain strategic materials can for later use to meet critical national needs. The space and aeronautics base of this country must be continually exercised by a sufficient number of things to do that will challenge most of the key actors to stay around. There is much concern that this base may be following the same course as the U. S. steel and automobile industries, the eastern railroads and perhaps of more relativeness, the defense industrial base[1]--albeit for quite different reasons.

A reading of such diverse documents and reports as the Hearth Study of Project Management and The Report of the Seasat Failure Review Board lead one to clearly worry about the "wasting away" of the current base of this country's aeronautical and space capability. To maintain this base at an effective level requires such actions as:

1. Sufficient funds for the selection of a few projects for in-house execution. Only through this approach can NASA be a sophisticated buyer and an effective manager of contractor space and aeronautical projects and activities.

2. Additional "up front" funds to assure that whatever new projects are authorized are adequately defined. "Up front" dollars for definition phases

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1/ See The Ailing Defense Industrial Base: Unready For Crisis, Report of the Defense Industrial Base Panel of the Committee on Armed Services, House of Representatives, Ninety-sixth Congress, Second Session, December 31, 1980.

are the "cheapest" project dollars there are.

3. Adequate funding of whatever projects are authorized to complete them effectively including adequate funds for systems engineering. The case of the shuttle is the most glaring example of not following this dictum. Had the initial commitment to the shuttle been kept the NASA 1981 budget would have been in the neighborhood of $7 plus billion instead of the actual $5.5 billion.

   Consistent underfunding for most programs over the last several years has increased the risk of technical failure, contributed to slipped schedules and markedly impacted adversely the performance of the NASA staff.

   > Basic to the Seasat mission was the concept of using an existing, flight-proven spacecraft bus for the services and housekeeping functions required by the sensors in order to minimize program costs and to permit concentration of effort on the sensors and their integration into the spacecraft.[1]

4. Find ways now to replenish the experienced professionals now leaving NASA and to improve NASA's ability to attract able scientists and engineers into the career civil service. This among other things means changes in the present conflict-of-interest laws and regulations and in pay.

1/ Report of the Seasat Failure Revirw Board, NASA, December 21, 1978, page 10-1. Underlining supplied.

The average age of NASA scientific and engineering personnel is about 44 -- having risen from 40 in the early 1970's. Earlier this year 167 of the key staff were reemployed annuitants, including the Director of the Johnson Space Center and the Shuttle Program Manager.

5. Take such steps as those being explored by NASA's Solar System Exploration Committee (SSEC):

> is simply that most future missions will have to be made simpler and cheaper than they have been in the past. Unlike Voyager or the Viking Mar's landers, they will not advance the state of the art. They will use standard spacecraft designs and off-the-shelf instrumentation as much as possible. They will also tend to carry fewer instruments, and will focus very sharply on specific scientific questions.[1]

6. Last, but not least, fund the major projects and activities that were deferred in President Reagan's budget revisions of March 10, 1981.

In conclusion, if all these actions and similar ones do not sustain the U. S. aeronautical and space base more drastic actions must be taken. Chief among these is to "resize" the present NASA base and reduce it in line with the size of today's and the future aeronautics and space program. Since the early 1960's NASA's funding has dropped from $16.5 billion to $5.5 billion in 1981 dollars. Many believe that NASA is currently larger than it needs to be to prosecute effectively the present

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1/ "To The Planets Cheaply," Science, September 18, 1981, page 1350.

aeronautics and space programs.

Failure to face up to what is happening to the U. S. aeronautics and space base capabilities violates a basic rule of tactics and politics -- "keeping your options as long as you can."

Let me thank you for the opportunity to appear before the Committee today. Thank you, Mr. Chairman and Members of the Committee.

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Mr. **Flippo**. That is indeed a very effective summary. One question immediately arises: you assume that very few political leaders will make a stand on the specific future space programs when they come face to face with trade-offs in social security and reduction in student assistance and other programs affected by our immediate social well-being: Should future space programs be considered part of our social well-being? Do you believe that people will continue to support our space program considering the recent social program budget cuts?

Mr. **Young**. I think that is debatable. My impression is that support for the space program is a disaggregated market, and that when you look at the situation have you a tendency to blame NASA and my friends down there for not doing a good sales job. There are many groups that have to be convinced that this is in the general welfare. I personally believe that, even though the theory of general welfare is a little difficult to come by with as many interest groups as we have. However, the various interest groups, such as the universities, which have a tendency to want the money but are terribly ineffective in coming to your aid and to convince your associates that the votes are needed for the space program. But with the disaggregated picture that space presents it does not have a single effective constituency.

Therefore, those who believe in the program must get as many different people to support the program, universities, people who benefit from weather, people who benefit from Earth satellites, resource measurements and so on, but those are terribly disaggregated groups. It makes it very difficult for people in your position to do what you are trying to do.

Mr. **Flippo**. Do you personally believe that the continuation of these programs that we have under NASA is essential to the long-range future of this Government?

Mr. **Young**. No question, starting out with national defense right down through such things as commercial aircraft.

Mr. **Flippo**. Do you believe, then, that some programs must be preferred over others? In other words, you must make some distinction between cutting all programs in times of extreme budget constraints?

Mr. Young. Absolutely, but relative priorities have to be set in a political context.

Mr. Flippo. As a former member in the OMB area, do you feel that the structure is available to impact OMB and the administration to emphasize the necessity of funding?

Mr. Young. Absolutely, absolutely. I think a great deal of mythology has grown up as to what OMB in itself does. Particularly, I think if it had not been for the Bureau of the Budget, OMB, science itself would not have been as well funded as it has been. Now, where OMB and the examiners and so forth get fairly upset and carry out their directions is where it comes to demonstrations or, as General Stafford talked about, making the Shuttle operational, because those are huge sums of money.

But when it comes to protecting space research, research generally across the board, you will find that the values among those people are probably as good as there are in the country, because they sort of fear political interference from the White House and from the Hill as not understanding science. But when it comes to the big things like making the Shuttle operational, that is when they cringe, because that is where their political bosses give them targets, these days ceilings.

Mr. Flippo. Mr. Brown.

Mr. Brown. I have no questions at this point, Mr. Chairman.

Mr. Flippo. Mr. Lowery.

Mr. Lowery. Mr. Chairman, I have no questions.

Mr. Flippo. The problems that we face here are many, we have OMB making these judgments, we hear NASA criticized for not tooting their own horn, and we wonder how can we build a political base to justify the expenditures, and that sort of thing. Are you aware of any executive order or any pressure on NASA that would prohibit them from more effectively communicating?

Mr. Young. To the best of my knowledge no. But I have not been involved in these kinds of things for the last 3 years personally. But to the best of my knowledge there is no such piece of paper. There are the normal constraints on members of administration not to support the President's budget. You people understand this as well as they do, but also you have got to realize that NASA, by the nature of its people, are not big promoters, just the nature of who they are. It just doesn't make them merchandisers.

Mr. Flippo. Thank you very much. Yes, Mr. Lowery.

Mr. Lowery. I do have a couple of questions. Following up on personnel, it strikes me that we have a real gap in terms of experienced professionals, engineers, and the like. How do you see us resolving that problem? There are professionals who are leaving NASA, and the fact that the younger engineers who left the aerospace industry in the 1960's and early 1970's, and any of them are not there anymore.

Mr. Young. The situation will probably worsen as opportunities in science and engineering grow in other sectors. You are not going to like the answer. Give them decent programs and pay them decently. That is a pretty crummy answer but it is straightforward.

Mr. Lowery. I don't object to the answer and I appreciate your candor.

A followup question. You were at NASA at a very critical time, 1966-73—excuse me, at OMB—when we had probably our most stellar achievements. We have heard a good deal of testimony about our long-range space goals, even the suggestion of a 20-year space plan. Is there any way that we can establish long-term goals that would not be subjected to the whims of each intervening administration?

We had such a commitment. President Kennedy articulated the goal of a man on the Moon within 10 years, so that through several generations of administrations after that we kept that commitment. Now we don't have any clearly defined objectives and commitments to meet. Do you have any suggestions as to how we might meet this?

Mr. YOUNG. My opinion is that you never in this country have clear, precise objectives, except when there is a clear external threat, because otherwise we operate in our normal pluralistic political way of doing things. This isn't all that bad, but it is only when you get a clear threat like death that gives a war on cancer, or the enemy overrunning you technologically, and so forth, that you clearly come to clear objectives. It is not within our political system.

Mr. LOWERY. We needed sputnik to have a policy?

Mr. YOUNG. You had to have the hell scared out of you to do anything.

Mr. LOWERY. Thank you very much.

Mr. FLIPPO. Thank you very much, Mr. Young. The importance of your testimony is certainly not measured by its brevity. We deeply appreciate it.

Mr. YOUNG. It was brief.

Mr. FLIPPO. It was very important.

Our final witness is Mr. Hank Koehn, vice president in charge of the futures research division at the Security Pacific National Bank in Los Angeles. Mr. Koehn has spent 18 years working in the area of computers and data processing for businesses to solve production and accounting problems before getting into futures research. He has recently completed a report entitled "Capitalism Goes Into Orbit," which makes the point that space colonization and space industrialization are neither farfetched, half-baked, nor very far from realization.

I think it is very auspicious that we wind up our hearings with a banker who is also a futurist. It is a pleasure to have you. We appreciate your coming the long distance, and please proceed as you deem appropriate.

[A biographical sketch of Mr. Koehn follows:]

HANK E. KOEHN

During the past twenty years Hank has had three business careers.

The first included data processing operations and management assignments in the manufacturing community. The second career included data processing systems analysis in both manufacturing and banking. The third and most recent includes planning and futures research. As Vice President of the Futures Research Division of Security Pacific he observes and comments upon technological developments and life style changes.

He has served state and national banking committees concerned with Electronic Funds Transfer Services. Hank is a member of United Way of America's subcommittee for Environmental Scanning, the United Way Region Five Planning Council, and the Five Year Planning Committee of the Los Angeles County American Lung Association. In addition Hank is on the Board of Directors of the Red Cross of Southern California and is their Vice President for Long Range Planning. He is also a guest lecturer for the U.S.C. School of Continuing Education.

Hank is listed in Who's Who In The West. He is a member of the National Association of Bank Women, a contributing editor for the Journal of the NABW, and the author of a newsletter called Future Scope for the Association for Systems Management.

STATEMENT OF HANK E. KOEHN, VICE PRESIDENT, FUTURES RESEARCH DIVISION, SECURITY PACIFIC NATIONAL BANK

Mr. KOEHN. Thank you. I would like to begin by making a statement as a corporate futurist employed in a large commercial bank. One of the assumptions that fits into all of our long-range scenarios is that the United States will continue the space program, for without that there seems to be no purpose in moving into the 21st century.

I would like to provide a brief summary of the testimony that I prepared for today and then, if it is your pleasure, I would be delighted to take some questions.

The history of America has been written in frontiers. It has been a succession of frontiers which have been discovered, explored, utilized, and then settled. Each frontier has provided a challenge and a great opportunity. Our acceptance of these challenges, our eagerness in pursuing these opportunities have produced great reward and, of course, ultimately great challenge.

Socially, culturally, spiritually, artistically, psychologically, and politically—as well as economically—we are and always will be a frontier nation. We need a frontier not only to remain true to our national character, but as a depository of our dreams and aspirations. Yet the frontier mentality is dangerous in a highly structured urban industrial society.

The outlet, clearly, is space, our next great frontier.

Neither our resources nor our prospects are limited. Human activity is no longer confined to the Earth's surface. Our economic system, therefore, does not have to be based upon the redistribution of Earth-bound resources, as it has been until the present. There is clearly a future for growth. Those who would choose to limit their vision to remaining on Earth choose against not only growth and development, but against America's past by trying to deny its future. We cannot turn our back on the frontier that awaits us. The utilization, industrialization, and colonization of space can, must, and will be the driving force of American life in the next century.

The movement to space will require great investment, but the payoffs will return many times the outlay in ways both numerous and probably ways that we cannot foresee today. For instance, the study of chlorine reactions in the upper atmosphere of Venus led to the discovery that fluorocarbons were dangerous here on Earth.

Being part of the financial community, I am aware of the importance of risk-taking capitalization. Being an officer of a bank which services the aerospace industry, I am aware that ventures of this order of magnitude cannot be designed to cost. We are all very proud of the Space Shuttle and so we should be—it is a magnificant machine. But it is not the Shuttle it could have been, what its designers knew it should have been: a fully reusable two-stage vehicle. Why? Because NASA's development funds were cut.

It must be remembered that space program money is not spent in space but on space here on Earth, creating new jobs, stimulating economic growth.

You have already heard from previous witnesses on the economic successes we have already seen. I am sure they made the point that the hundreds of technological breakthroughs and spinoff products that have been created were not planned or foreseen—they grew out of the fertile atmosphere of incentive, commitment, and willingness to take risk.

The future is not something that just happens to us. It is not remote from us. We create it every day by our beliefs, our behavior and things we move toward. Our image of the future, as a nation and as individuals, conditions our behavior toward actions that will bring that future about. Why not then create a positive, affirmative future by imaging that future and working toward it?

I would like to present briefly such an image of the next 10 to 50 years. It might look something like this. Realizing the vast potential of space—or perhaps unfortunately galvanized by the aggressive pursuit of space operations by the Soviets, Japanese, and Europeans—the United States recommits itself to a vigorous space program. The primary focus is a large, permanently manned space station to take full advantage of the Space Shuttle's capabilities, but the program includes planetary, solar, and other probes into deeper space.

We begin to industrialize nearby with humans, explore afar with robots. I believe this is key. There is a place for both humans and robots in exploring beyond the Earth's surface. A new commercially oriented consensus is reached between government and industry. Like the opening of new frontiers in the past, a rise in optimism is brought to society, a renewal of national excitement, pride, and confidence. The multiplier effect of dollars spent on space stimulates our economy to growth.

Private firms conducting space processing of organic and inorganic materials start to reap rewards and favorable rates of return.

A large platform capability is developed. A solar power satellite system takes shape, along with a Moon mining base.

The movement of numerous industrial operations to space, where there is nothing to pollute yet an abundance of materials and energy to utilize, starts to have favorable effects on the Earth's problems of pollution and natural resource depletion. Developing countries are brought into the world's technical, productive economy through space services, raising their levels of wealth. World population pressure begins to decline.

The general global advance fostered by space activities brings about a high level of international cooperation and peace. Technologies developed in space and for space eradicate disease, achieve safe, nonpolluting, unlimited fusion energy, and provide the solution to nuclear waste disposal.

This brief scenario is, admittedly, a very favorable one. But by basing decisions on such a vision we can bias our future in a positive way. Being visionary is practical, you see.

All of the space programs I have mentioned, the space station, space platform, and space processing in the short run, solar power satellites, and Moon mining a bit further out, could be wonderfully fruitful investments in our future. All relate intimately to immediate conditions on Earth. Our goals in space are directly defined in terms of our earthly activities. Even exploratory probes teach us more about our universe and therefore more about ourselves. The universe is man's environment.

Every new territory we have ventured into has at first appeared strange, hostile, and useless. Alaska, now an immense national resource, was said to be a vast wasteland. The Great Plains, now the greatest source of food known to man on the planet's surface, was called the Great American Desert. So too will it be with space.

It is believed to be the solution to many of those problems. Just as second-wave technologies of the industrial era helped solve the problems of productivity and distribution that first-wave agriculture was experiencing at the beginning of this century, so too will third-wave high technologies, particularly those of space science and applications, help solve—by the end of the century—many of the problems that industrialization has experienced, including pollution, natural resource and energy depletion, overpopulation, food shortages, war, dehumanization, and alienation.

By planning future space programs with an eye toward earthbound problems, we can put ourselves in a position to invent the future, to invent new social structures, organizations, even new and vastly more appropriate languages. Our opportunities exceed our fantasies. A new frontier means new lands, new wealth, expansion, and growth. We must think clearly in future terms. Of course there are immense problems to be overcome. But to erect institutional, organizational, or political obstacles in our path at this point would be tragic and unnecessary, when so many—if not all—of the needed technology already exists. Indeed in the opinion of many of us, we have wasted the last 10 years.

We must provide the inducement and promote the efforts, so that the challenges will be accepted and opportunities exploited. The move into space exploitation from space exploration is especially challenging for the private sector because most of the required capital, incentive, and willingness to take risk will and must come from free business enterprise, albeit with the aid and encouragement of the public sector.

The very concept of a corporation grew out of the challenges and opportunities to explore the new world. A new alliance of government and business is now required for the new world of space, one that is far more commercially oriented—in the granting of proprietary rights, for example—than now exists, or clearly the Soviets, Japanese, and Europeans will leave us behind. Between 1961 and 1969, NASA poured more than $20 billion into the computer, semiconductor, and aerospace industries. It assumed much of the risk for long-term research and development and encouraged close cooperation between business and government.

It dispensed funds to a wide variety of companies, providing seed money for new ventures as well as bolstering established giants. The 1960's, as a result, were a time of great technological development, economic growth, and national optimism. Today, in fact, all of those industries are the very key to our economic future.

During the 1970's, on the other hand, space funding was cut back, and we suffered recession, stagflation, and national malaise. The connection here is not tenuous: technological advance is the primary source of higher productivity and economic growth—and perhaps of our collective psychological growth of our society as well.

The benefits of putting government money into young, dynamic, high technology industries are clear and proven. Whole future industries could develop out of experiments being conducted on the Space Shuttle. We must provide the incentive for these industries to make their products commercially viable.

Space industrialization offers new options for future growth. The space environment offers advantages that are extremely attractive for industrial operations: controllable gravity, vacuum, temperature, and purity, and virtually free energy. Near-term goals are obvious and they are threefold:

One, to furnish space-derived services for which agencies, industries, and the public are willing to pay;

Two, to provide space-derived products or goods that are saleable and profitable; and

Three, to provide inexhaustible, nonpolluting energy from space.

One. In one key area, information services, the industrialization of space has already begun. Satellites are revolutionizing worldwide communications. Commercial investments in these satellites now total well over $1 billion. The use of satellites for weather tracking, navigation, mapping, resource surveys, and observation is also extensive. Moving beyond information acquisition, there are vast opportunities:

Two. Products from space processing and manufacturing will include those organic, such as isoenzymes, insulin, and new antibiotics; and those inorganic, such as crystals, circuits, and new alloys.

Three. Possibilities for energy from space include solar satellite power collectors transmitting energy to Earth via microwaves or lasers for conversion to electricity and distribution; and solar satellite reflectors for night illumination of urban areas and of agricultural and industrial operations, for disaster relief operations, for climate manipulation and control.

Space exploitation will include great risks. That is why the incentive of profit is necessary and why private enterprise will be a major vehicle. Rewards, too, will be great, for the successful, and that is as it should and must be. There should be no fear of risk, failure, mistakes, and losses, for they are the educators that come hand-in-hand with success, progress, improvement, and growth. And there is no alternative to economic growth. It is a social necessity, the only knit that can keep the fabric of modern civilization from unraveling.

As Ben Bova has pointed out, in his recent book on space, other nations have faced this choice. Five hundred years ago, the Chinese had developed deepwater navigation to the point that their trading ships could tap the wealth of commerce to be had along the Indian and Pacific Oceans. But abruptly the Ming Dynasty decided to keep its people tightly bound to their own shores. Within a century, China was being picked apart by Europeans, who found a backward, ignorant nation that was already fragmenting into petty principalities.

That is, clearly, one past we must not allow to become prolog to our own future.

In conclusion:

One. The future belongs to those who decide to build it. Although a primary motivation for the industrialization of space will be economic expansion, the opportunity for human expansion is offered as well. Today only the motivation is missing.

Two. Space industrialization is not only a great and promising project, it is a logical and essential part of the human adventure. In the long run, the knowledge that civilized humanity was expanding and developing off the planet's surface could have a crucial effect on the outlook of mankind.

Three. A perceptual shift is required that understands this great transition is necessary, yet not inevitable, it must be made to happen. We can no longer postpone our response to this challenge; we must make the high frontier mankind's highest home.

Four. Ideas, if they gain the resources, can move mountains; trends of thinking, powerful and persuasive, can shape events. Vision is one of the most powerful of human motivations. Many talents are needed to fulfill such a vision as space exploitation. There is room for all in our society to make a contribution and for all to benefit from the knowledge gained and riches produced.

I believe that all of our vision and especially your efforts are needed today.

[The prepared statement of Mr. Koehn follows:]

Planning Today For Future Space Programs

Prepared Statement

of

Congressional Testimony

before the

Subcommittee on Space Science and Applications

Committee on Science and Technology

U.S. House of Representatives

by

Hank Koehn
Vice President
Futures Research Division
Security Pacific National Bank
Los Angeles

Wednesday, September 23, 1981, 9:30 A.M.
Rayburn House Office Building, Room 2325

Don Fuqua, Chairman, Committee on Science and Technology

Ronnie G. Flippo, Chairman, Subcommittee on Space Science and Applications

It is a pleasure to be here before the Subcommittee on Space Science and Applications of the House Committee on Science and Technology, to present testimony concerning "Planning Today For Future Space Programs".

I have a brief statement that I would like to present to the Subcommittee, after which I would be delighted to take questions concerning my testimony.

Mr. Chairman, I am Hank Koehn, Vice President of the Futures Research Division of Security Pacific National Bank, Los Angeles.

As the corporate futurist it is my responsibility to monitor the signals of change which indicate how our society and world are fundamentally changing as we move into the future.

The end products of my work are scenarios of possible and probable alternative futures.

Planning Today For Future Space Programs

The history of America is written in frontiers: a succession of frontiers discovered, explored, utilized, and settled.

Each frontier with which we have undergone this cycle has provided great challenge and opportunity.

Our acceptance of these challenges, indeed our eagerness in pursuing these opportunities, have produced great reward (and great change).

Stupendous material benefits are only a part of the enrichment produced by our past willingness to take risk for the sake of the future.

Socially, culturally, spiritually, artistically, psychologically, and politically - as well as economically - we are and always will be a frontier nation. We need a frontier not only to remain true to our national character, but as a depository of our dreams and aspirations. Yet the frontier mentality is dangerous in a highly structured, urban, industrial society.

The outlet, clearly, is space, our next great frontier.

Neither our resources nor our prospects are limited. Human activity is no longer confined to the Earth's surface. Our economic system, therefore, does not have to be based upon the redistribution of earthbound resources. There is a future for growth. Those who would choose to limit their vision to remaining on earth choose against not only growth and development, but against America's past by trying to deny its future. We cannot turn our back on the frontier that awaits us. The utilization, industrialization, and colonization of space can, must, and will be the driving force of American life in the next century.

The movement to space will require great investment, but the payoffs will return many times the outlay in ways both numerous and unforeseen. (The study of chlorine reactions in the upper atmosphere of Venus, for example, led to the discovery that fluorocarbons are capable of breaking down Earth's protective ozone layer).

Being part of the financial community, I am aware of the importance of risk-taking capitalization. Being an officer of a bank which services the aerospace industry, I am aware that ventures of this order of magnitude cannot be designed to cost. We are all very proud of the Space Shuttle and so we should be - it is a magnificent machine. But it is not the shuttle it could have been, what its designers knew it should have been: a fully reusable two-stage vehicle. Why? Because NASA's development funds were cut.

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That image (let's say, of the next 20 to 50 years) might look something like this: Realizing the vast potential of space (or galvanized by the aggressive pursuit of space operations by the Soviets, Japanese, and Europeans), the U.S. recommits itself to a vigorous space program. The primary focus is a large, permanently manned space station to take full advantage of the Space Shuttle's capabilities, but the program includes planetary, solar, and other probes into deeper space.

We begin to industrialize nearby with humans, explore afar with robots. A new, commercially-oriented consensus is reached between government and industry. Like the opening of new frontiers in the past, a rise in optimism is brought to society, a renewal of national excitement, pride, and confidence. The multiplier effect of dollars spent on space stimulates our economy to growth.

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The movement of numerous industrial operations to space, where there is nothing to pollute yet an abundance of materials and energy to utilize, starts to have favorable effects on the earth's problems of pollution and natural resource depletion. Developing countries are brought into the world's technical, productive economy through space services, raising their levels of wealth. World population pressure begins to decline.

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I have just indulged in a very favorable scenario. But by basing decisions on such a vision we can bias our future in a positive way. Being visionary is practical, you see.

All of the space programs I have mentioned, the space station, space platform, and space processing in the short run, solar power satellites and moon mining a bit further out, could be wonderfully fruitful investments in our future. All relate intimately to immediate conditions on earth. Our goals in space are directly defined in terms of our earthly activities. Even exploratory probes teach us more about our universe and therefore more about ourselves. The universe is man's environment.

Every new territory we have ventured into has at first appeared strange, hostile, and useless. Alaska, now an immense national resource, was said to be a vast wasteland. The Great Plains, now the greatest source of food known to man, was called "The Great American Desert". So too will it be with space.

Space does not represent an area of endeavor that should be undertaken only after the problems here on earth are solved - it may well be the solution to those problems! Just as second wave technologies of the industrial era helped solve the problems of productivity and distribution that first wave agriculture was experiencing at the beginning of this century, so too will third wave high technologies, particularly those of space science and applications, help solve (by the end of the century) many of the problems that industrialization has experienced, including pollution, natural resource and energy depletion, overpopulation, food shortages, war, dehumanization and alienation.

By planning future space programs with an eye toward earthbound problems, we can put ourselves in a position to invent the future, to invent new social structures, organizations, cven new languages. Our opportunities exceed our fantasies. A new frontier means new lands, new wealth, expansion, and growth. We must think in future terms. Of course there are immense problems to be overcome. But to erect institutional, organizational, or political obstacles in our path at this point would be tragic and unnecessary, when so much (if not all) of the needed technology already exists. Indeed, we have already wasted ten years.

We must provide the inducement and promote the efforts, so that the challenges will be accepted and opportunities exploited. The move into space exploitation from space exploration is especially challenging for the private sector because most of the required capital, incentive, and willingness to take risk will and must come from free business enterprise, albeit with the aid and encouragement of the public sector.

The very concept of a corporation grew out of the challenges and opportunities to explore the New World. A new alliance of government and business is now required for the New World of Space, one that is far more commercially oriented (in the granting of proprietary rights, for example) than now exists, or the Soviets, Japanese, and Europeans will leave us behind. Between 1961 and 1969, NASA poured more than $20 billion into the computer, semiconductor and aerospace industries. It assumed much of the risk for long-term research and development and encouraged close co-operation between business and government. It dispensed funds to a wide variety of companies, providing seed money for new ventures as well as bolstering established giants. The '60s, as a result, were a time of great technological development, economic growth, and national optimism. Today, in fact, those industries are the very key to our economic future.

During the 1970s, on the other hand, space funding was cut back, and we suffered recession, stagflation, and national malaise. The connection here is not tenuous: technological advance is the primary source of higher productivity and economic growth (and perhaps of our collective psychological health as well).

The benefits of putting government money into young, dynamic, high technology industries are clear and proven. Whole future industries could develop out of experiments being conducted on the Space Shuttle. We must provide the incentive for these industries to make their products commercially viable.

Space industrialization offers new options for future growth. The space environment offers advantages that are extremely attractive for industrial operations: controllable gravity, vacuum, temperature, and purity, and virtually free energy. Near-term goals are threefold:

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2) to provide space-derived products or goods that are saleable and profitable, and
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1) In one key area - information services - the industrialization of space has already begun. Satellites are revolutionizing world-wide communications. Commercial investments in these satellites now total well over a billion dollars. The use of satellites for weather tracking, navigation, mapping, resource surveys, and observation is also extensive. Moving beyond information acquisition, there are vast opportunities:

2) Products from space processing and manufacturing will include those organic, such as isoenzymes, insulin, and new antibiotics; and those inorganic, such as crystals, circuits, and new alloys.

3) Possibilities for energy from space include solar satellite power collectors transmitting energy to earth via microwaves or lasers for conversion to electricity and distribution; and solar satellite reflectors for night illumination of urban areas and of agricultural and industrial operations, for disaster relief operations, for climate manipulation and control.

Space exploitation will involve great risks. That is why the incentive of profit is necessary and why private enterprise will be a major vehicle. Rewards, too, will be great - for the successful - and that is as it should and must be. There should be no fear of risk, failure, mistakes, and losses, for they are the educators that come hand-in-hand with success, progress, improvement, and growth. And there is no alternative to economic growth - it is a social necessity, the only knit that can keep the fabric of modern civilization from unraveling.

As Ben Bova has pointed out, other nations have faced this choice. 500 years ago the Chinese had developed deep-water navigation to the point that their trading ships could tap the wealth of commerce to be had along the Indian and Pacific Oceans. But abruptly the Ming Dynasty decided to keep its people tightly bound to their own shores. Within a century China was being picked apart by Europeans, who found a backward, ignorant nation that was already fragmenting into petty principalities.

That is one past we must not allow to become prologue.

In conclusion:

1) The future belongs to those who build it. Although a primary motivation for the industrialization of space will be economic expansion, the opportunity for human expansion is offered as well. Only the motivation is missing.
2) Space industrialization is not only a great and promising project: it is a logical and essential part of the human adventure. In the long run, the knowledge that civilized humanity was expanding and developing off the planet earth could have a crucial effect on the outlook of mankind.
3) A perceptual shift is required that understands this great transition is necessary, yet not inevitable - it must be made to happen. We can no longer postpone our response to this challenge; we must make the high frontier mankind's highest home.
4) Ideas, if they gain the resources, can move mountains; trends of thinking, if powerful and persuasive, can shape events. Vision is one of the most powerful of human motivations. Many talents are needed to fulfill such a vision as space exploitation. There is room for all to make a contribution, and for all to benefit from the knowledge gained and riches produced.

Your vision and your efforts are especially needed today.

Thank you.

Mr. **Flippo**. Mr. Koehn, thank you very much for some very thoughtful and well-stated comments. Many of your remarks are very quotable and I suspect that some Members of this committee will quote them.

Mr. **McGrath**. I suspect all will.

Mr. **Flippo**. One particular area—there are so many areas of profitable exploration in your remarks, but one in particular strikes me: You talk of a new structure, perhaps a new cooperation between industry and government, a new method of exploitation, of moving forward. We have one particular area that I would like to discuss with you. You know the Landsat program seems not to be making as much progress as we would like it to, and some feel that it is time to transfer that into the private sector.

There is some discussion about that, about trying to find an appropriate vehicle. You mentioned the close relationships in Japan and other nations between their industry and their government. We are trying to find some vehicle that would protect proprietary interests and let us go forward. You being a banker and working in the financial end of it, I think your insight might be helpful. Are you familiar with the Electric Power Research Institute and how it operates?

Mr. **Koehn**. No, I am not.

Mr. **Flippo**. Do you have any suggestions as to the type of structure that would be necessary to have a better relationship between government and business? It is not a problem, really, of transferring technology, because technology transfers almost by osmosis, but the problem lies in how do you transfer the financial responsibility?

Mr. **Koehn**. One of the interesting things you mentioned is the Landsat possibilities. Translation of Landsat data is not particularly easy. Only a few places on Earth seem to understand it. Of course, the threat with the Landsat is clearly the threat perceived in the transport of data flow issues by the less developed countries.

If you have a Landsat going overhead, and say a large hotel chain in the United States, knowing the readings of the Landsat data announces they want to build a hotel in a less developed country and stimulate tourism, when of course they realize they read radium under the ground and as they start to dig they pretend there is a discovery and, of course, switch from hotels to mining. That could be kind of dangerous and it is the kind of exploitation that the less developed countries fear, but it is a perfect example of unleasing now something that has been going on, hopefully in a civilized way, so that that information can indeed be used. But you can't expect any business enterprise to go into any activity unless it thinks that it will have the first opportunity to exploit the results.

I believe, from the things that I have read, that it would be very possible for several large corporations in the United States to come together and move into the space program themselves, using things like the Earthport project, a private group that is trying to start something on the equator, and taking, indeed, the entire commercial venture out of the hands of the United States today, and perhaps be competitive with the Europeans and the Japanese, but you have to produce that incentive almost like patents and copyright protection, at least for a given number of years, that they can afford to exploit it.

Mr. **Flippo**. Mr. Brown.

Mr. **Brown**. I would like to add to what the chairman has said about the value of the testimony you have given. I wish there were more individuals in the business world who thought in these terms and could help us develop that link between Government and business which seems to be a key ingredient of what we are trying to do. The level of discussion that exists right now seems to preclude getting together and working out some of these scenarios and developing cooperative programs to reach them.

I would like to have you react to that just a little bit. I think there are people of vision in business, as there are in universities and maybe a few in Government, although not too many, and my question is: Is there some way that we can encourage this transition to a more cooperative relationship? We see this as a necessity, no matter which way we look at this problem of what is wrong with the country today, whether we are looking at the future space programs or general questions of productivity in the country. They are all related in some way. The inspiration of the new frontiers, which you have indicated is a significant element, seems to be a factor that could inspire us to new achievements in a lot of different fields.

How do we bring this about?

Mr. **Koehn**. One of the problems with business—and this is a very, I guess, generously called candid comment—actually it is quite blatant—in the United States in the last 25 years is that we seem to be evolving a business executive as a byproduct of the Second World War that fears risk. There is a certain amount of fear of risk. The beginning thing is keep your nose clean. Don't do anything risky. We have evolved perhaps too many executives that are just managers that were designed by education and background to maintain that which was, rather than having a vision of that which could be. We somehow for almost two decades lost the entrepreneurial spirit although research indicates that it is coming back and that it could be encouraged.

The easiest way of helping to do that and the techniques that we use is to create, and I never create one scenario, this was one but you should create perhaps at least two scenarios, boundary scenarios, and one, of course, would indicate that the United States had not gone into space and this would take no more than 5 pages but that, of course, the Europeans and the Japanese have, and the Japanese have a perfect understanding of what space is about and they are coordinating the efforts. So we would place them in space 20 years in the future, and have us buying all services from them.

Now, I don't think Americans would be overly comfortable with that, buying it from anyone, because of our national attitude. Our own business executives, who are merely managers, would be uncomfortable by that arrangement too, so we would create two visions—one in which we did not go ahead, but others did.

The fact that we are not going ahead seems to have the assumption that if we don't do it no one else can do it, and of course that is ridiculous. The Chinese are even successfully launching satellites today, so we would have one vision in which we didn't, and the lost opportunities would be very obvious, or the price we would pay for participating in what was gained would be obvious, and the other is the kind of thing that we have talked about today, that we do go ahead, and throw them out as two choices, and with the added question of where do you fit into either of those choices.

Well, in the one in which we were not into space, we would clearly be a buyer, where the obvious choice on the other side that you would be a provider and a seller, and that you would be expanding the economy beyond just the redistribution of what is located on the planet's surface.

You see, one of the images in this room, the picture on the other wall, shows that all that we have now is to just redistribute what is already there, so I think the two images, they are rather electrifying. They don't have to be very long. In fact, the briefer they are, and say OK, where do you fit in, which one do you like, and I can't imagine with our national attitude we would like buying something that we think we should be leading in.

Mr. Brown. But as has been pointed out by earlier witnesses, we don't have an institutionalized capacity for doing that. For example, in NASA, which was our lead agency in space, they are not in the business of creating these scenarios of what could be the situation 20 years from now, and neither is business apparently at this point, for the very practical reason that if you commit yourself to a program based upon a truly long-range projection, you tend to take present resources and devote them to the long-range program, and it reduces your current level of return on capital, and this is perceived as being adverse to the current competitive situation.

You could easily point out how in the long run, it is indispensable to maintaining a competitive position, but it is the short run that seems to get the undue emphasis today. You have pointed this out as a characteristic of today's managers, and others have also, and yet I don't see a good way in which we can change that without what you might almost describe as a religious conversion. That is, a sense that the future is more important than we are presently giving it credit for.

Mr. Koehn. Mr. Brown, I don't think that is all bad. You used the word "religious" conversion. Religious conversion is based upon two things, none of which NASA perhaps seems to have; maybe they are dispirited. But a religious conversion is based on, first, an image and then a hell of a lot of PR, and the vision seems to be lacking at the moment. Even with a positive scenario, the PR seems unbelievably weak. The best PR that has happened recently was, of course, the safe return of the Columbia.

That is the reason in my testimony I suggested that there has to be a judicious balance between robot exploration and the use of humans. The movement toward the rings of Saturn brought to the public's attention in living color an excitement and it was relatively safe and relatively inexpensive because it was a robot, it was unmanned. Even if it had been destroyed, although we have almost tended to think of that robot as a living entity and an extension of us, it was a safe bet.

We need that mix so we can bring back those exciting images at the same time trying something close in, and that is the whole success of the type of work that I do. It is creating an image, sometimes a bad image, to give someone something to throw against and object to, and there is a touch of religious conversion to it, but there is an awful lot of PR, and I don't see good PR coming out of those activities right now.

In fact, once again, this room is interesting. It contains a mix of pictures, some of which are real from the past and some of which will be real from the future, and cleverly done. It would be hard to tell which was real.

Mr. BROWN. You have given us some fascinating examples. What if the Ming Dynasty had these scenarios and really perceived the consequences of their retreat from the technology of commerce as they had developed it; I think it would have changed the future of China at that time. We have similar situations today. Our obsession with short-run successes, for example, in the automobile industry, has precluded a more successful long-range future. Now, that can be overcome if we perceive the error of our ways quickly enough, but it always requires a traumatic readjustment, and some of our major industries are going through that right now.

Mr. KOEHN. You may have the external threat you need, only I don't think it is obvious to most business people, and that is the threat, if you perceive it in these terms, of the Japanese or the Europeans being there first and grabbing off the communications capability and providing essentially the communications and the sensoring capability for the entire planet. That would be perceived of as a great corporate threat, not quite as much as a war, but it is the negative portion of the alternate scenario.

Mr. BROWN. We see that already developing.

Mr. KOEHN. Yes.

Mr. BROWN. The preemption of global markets in electronics.

Mr. KOEHN. But we somehow seem embarrassed to bring it up or strongly project it outward.

Mr. BROWN. Thank you very much.

Mr. FLIPPO. Mr. McGrath.

Mr. MCGRATH. Thank you, Mr. Chairman.

Mr. Koehn, I want to commend you for an enlightening presentation, and certainly some very cogent remarks regarding the bullishness of some of the industries that are in this business. Sometimes what puzzles me a little bit regarding the availability of capital, risk capital, in an industry like this, particularly in a day and age where inflation rates are where they are, and it seemingly is going to take a little longer time than we suspected in order to get those interest rates down to where they might be reasonable and logical.

I am interested in pursuing with you where industry should get into the picture as far as space is concerned or any kind of scientific exploration, as far as basic research versus the demonstration versus the commercialization. Naturally, we all know where they want to get as far as the commercialization is concerned. How much risk capital should they be willing to expend in a venture such as this?

Mr. KOEHN. I wonder if I could touch on this just for a second. There seems to be more venture capital flowing around now than in the last few years, and curiously enough it is available in one of the most threatened industries at the moment, which is airlines, due to the airline deregulation. Now, while the major airlines seem to be having a great deal of trouble getting funding to assure their existence, you are having the emergence of a whole new array of small carriers—New York Airways, Midway, the Peoples Express. There seems to be no lack of funding for these small airlines that are shifting and finding a market, a segmented market—the Peoples Express to move people from Columbus to New York for 35 bucks a seat, you just get on and sit down. I mean, the whole point is moving from one city to another. So there seems to be venture capital in that industry even though the overall industry is threatened.

Mr. McGRATH. That is for a service. We are talking about for——

Mr. KOEHN. I am still talking first about services for space. I think that, yes, for service, but in the product line I would think that the first movement would be with the pharmaceutical industry, because the manufacturing facilities in space could be relatively small to begin to produce things like interferon or insulin or new drugs that are needed, and needed in a pure form, and we have already demonstrated we can do that. In fact, they now have them manufactured and they just want a better environment and we have proven that that environment does exist and that we have access to it and we can go to it. We can go to it with the Columbia itself, with the Space Shuttle.

I would think that the first industry, as you mentioned, for product might easily be back in pharmaceuticals. The first industries for service already exist. With the transfer of the Landsat program, you have already proven that regular satellite communication is not only viable but desirable. The incentive today to show internationally a prize fight and collect great sums of money by bringing it into other cities and enlarging the entrance fee to watch a big TV screen. So we have gone past that beginning of the service, and I think we can move into the product end rather quickly in the pharmaceutical field.

Mr. McGRATH. What kind of methodology can be developed, and how should it be developed in order to, say, repay or have government recoup some of the basic research and demonstration which they have funded practically 100 percent? How can that be factored in?

Mr. KOEHN. You could always place fees. When we explored the New World, which, as I said, it was rather interesting, the different approaches between the English and the Dutch and the exploration of the world with their sailing fleets as opposed to the Spanish and Portuguese. They created the corporation. Then you could always grant licenses and charge fees for participating in it, to recover some of that, much as you do with a large bridge.

For instance, in California the Golden Gate has already been paid for and they don't quite know what to do with the fees except for maintenance. But you could charge fees for going into that area, and over a prolonged period of time, three decades perhaps, begin to slowly recover and totally pay for the project.

Mr. **McGrath**. In light of the large expenditures over the years, in order to get to the position where we are able to provide the service and production in space, some of those fees might be too high for any industry to be able to absorb, who would buy the product under those conditions?

Mr. **Koehn**. I doubt that in the long term, it is a longer term look, but in two or three drugs alone, in interferon, which could possibly change the whole life expectancy of people who will be getting cancer, and as our society matures more and more, we are going to have a higher incidence of cancer in the next 20 years because people are living longer to get it. Those drugs could easily be worth pursuing. I think that it can be done.

You see, I am sure that when the English, Dutch, and the Spanish and Portuguese funded the first sailing ships—and certainly they didn't have any of the navigation tools; they did not even know where they were going—the return on investment there was seen as potentially zero. Yet they took the risk. At least we know where we are going.

Mr. **McGrath**. Mr. Koehn, I appreciate your approach. Thank you for being here.

Mr. **Koehn**. Thank you.

Mr. **Flippo**. Mr. Lowery.

Mr. **Lowery**. Thank you, Mr. Chairman.

I will be brief and I am happy to see Security Pacific has the crown jewels for outer space. I find your testimony cogent, exciting, quite refreshing, and I appreciate your good words. I also serve on the Banking Committee. For 9 months I have been looking for linkage between the real world of the financial community and the very forward-looking world of this committee, of science and technology, and you certainly have provided that linkage today. I find your comments very much to the point.

First, I have got to tell you I thought we were going to hear about 17-percent mortgage rates on the Moon, but you have done far more than that. I do thank you.

Mr. **Koehn**. Thank you.

Mr. **Flippo**. Mr. Koehn, I want to thank you very much for your testimony. We appreciate it. It has been very enjoyable.

This concludes our witnesses and concludes our hearings. Thank you very much. I want to thank all of the staff and all of the members for your great help and your attendance during this time, too. Thank you very much.

[Whereupon, at 12:20 p.m., the subcommittee adjourned.]

APPENDIX

THE LIBRARIAN OF CONGRESS
WASHINGTON, D.C. 20540

October 6, 1981

Dear Mr. Flippo:

I am enclosing a prepared statement for inclusion in your hearings on the future of space programs. The theme is more fully developed in my book, *The Exploring Spirit*, published by Random House in 1976. I appreciate your invitation to be part of this endeavor.

Sincerely yours,

Daniel J. Boorstin
The Librarian of Congress

Enclosure

The Honorable
Ronnie G. Flippo
Chairman, Subcommittee on Space
Science and Applications
Committee on Science and Technology
House of Representatives
Washington, D. C. 20515

LIBRARY OF CONGRESS

Statement of The Librarian of Congress
Daniel J. Boorstin
for Hearings before the Subcommittee on Space Science and Applications,
Committee on Science and Technology
U. S. House of Representatives

In America, exploration and growth have been synonymous. We have been an exploring nation, for the settlement of our nation, unlike others, has come along with the exploring of our land. The frontier which many have used as a hallmark of our history has been simply another name for the boundaries of the unknown. Much of the greatness, the optimism, the energy and the boldness of our country has come from this peculiar way of growing. In fact, the people who built America were not afraid to plunge into the unknown, to live on the edge of the unknown.

We are prone to forget some of the special characteristics of their experience. First, the uncertainty and the willingness to take risks. This was a meaning of the New World. When the Puritans came here from England and from Holland they moved to the edge of mystery. When people moved westward in the wagon trains in the nineteenth century, they moved across the unknown. When immigrants came from the countries of Europe in the nineteenth century, they moved into a world they did not know.

This exploration was undertaken in community. From Columbus in the late fifteenth century, who came by ship with his scores of fellows, down to the westward-moving wagon trains in the mid-nineteenth century, people organized themselves together to move more swiftly and more safely. The same was true of those who built the fur trade and their many successors who developed American enterprise. All these pioneers helped make it socially and spiritually possible for us to undertake our space explorations. Our classic American enterprises have been undertaken by large numbers of people organized and effective together.

The exploring spirit has expressed faith in the unpredicted and the unpredictable. Its theological form was a not-merely-ritual expression of belief in Divine Providence uttered again and again by George Washington and by his successors in the Presidency. The secular form of this faith in the unpredicted and the unpredictable was the Booster Spirit. Americans have been willing to buy stock in the future and to postpone benefits -- partly because our American future has always seemed to merge so conveniently into our American present. All this expresses our sanguine determination not to be afraid to detail the grand American future simply because it is not yet here. Enthusiastic Western newspaper editors on the Booster frontier thought there was no reason why they should not describe the rosy future simply because it had not yet (as they said) "gone through the formality of taking place."

The American nation has grown, for the most part, not by conquest but by exploration. Much of the vitality of American civilization in our century will depend on our ability to translate this exploring spirit, this enthusiasm for the unknown, into late-twentieth-century terms. This is not easy to do. We see some evidences of it in the spectacular recent growth of "Research and Development." Now "R & D," which has become a major enterprise of American business, is really a symbol in the world of industry of our quest for the unknown and the unpredicted.

But at the same time many of the peculiar influences in American civilization in our day -- in fact the very successes of American civilization in the twentieth century -- have tended to dampen or dilute the exploring spirit. The fantastic and unpredictable successes of our civilization have, among other effects, produced the following consequences in our daily lives.

First, there has been what I would call "the neutralization of risks." Some of the more obvious factors in this have been the growth of welfare government and the improvement of medicine and public health. A symbol of the neutralization of risks which has not been sufficiently noted has been the rise of insurance: unemployment insurance, health insurance, and (less noticed, although psychologically of equal importance) casualty insurance. The history of American casualty insurance -- the means by which Americans protect themselves from the risks of their daily lives -- begins as recently as 1864 when the Travelers Insurance Company was formed to issue travel accident policies. When, in 1868, a casualty insurance company began to inspect steam boilers, they pioneered modern techniques of loss prevention and helped develop new ways of indemnifying industrial enterprises for accidents. By 1898 there were fourteen companies sharing casualty premiums of some $11 million; by 1960 there were thirty-five hundred companies with total premiums of over $90 billion a year. The rise and diffusion of compulsory insurance in many forms, including "no-fault" insurance, is only the latest longest step. The effect of all these has been to encourage Americans to think that they can remove or at least reduce most of the risks of daily life.

At the same time the triumphs of American industry have led to the decline of the miraculous. We have seen the erasing of regions in our food, the erasing of seasons in our diet, by the rise of canning, refrigeration, and deep-freezing; then, too, the erasing of seasonal climates first by central heating, and in our time by air conditioning. Finally, the erasing of space itself by air transports. Radio and television have further eroded our sense of the miraculous. With television, it is even possible for us to be more there when we are here than when we are there.

An additional development of our industrial world has been the rise of repeatable experience: the new and ever-increasing opportunity to replay all the events of the past. It has its beginning with photography in the middle of the nineteenth century, advanced with the development of the phonograph and the motion picture, and has climaxed with kinescoping and instant replay, which do much to remove the spontaneity even of sports experiences.

Finally, as a result of these and other factors, there has been the crowding of the continent. The global view closes in. We note everywhere a decline of the risky, a decline of the unpredicted, a decline of the unknown. But space exploring has kept alive and stimulated the traditional American exploring spirit, it has reminded us of this spirit and developed our pride in that spirit. The uncertainties, the risks and the hopes of space exploring have helped us keep alive some of our oldest traditions: community, risk-taking, unknown-seeking. These have dramatized all our community efforts, for our moon shots are, of course, the greatest focused collaborative exploring efforts in history.

In our paradoxical nation, no paradox is more intriguing than the combination of our pragmatic spirit with our love affair with the unknown. It is appropriate that our new world should be the point of takeoff for newer worlds. By moving into outer space we have effected a change in mankind's point of view, we have lifted man above the petrified world he knows, much as did Copernicus and his followers in shifting from the geocentric to the heliocentric point of view. Now we direct man's view toward the new continents of outer space in the discovery of new Americas.

Just as the shift which came with the discovery and settlement of America changed Old World thinking about the world and at the same time provided a new locus of experience, so has space exploring. It has kept alive and vigorous, dramatically and symbolically clear, the exploring spirit which is the American mission. What might be the meaning of that mission for all of us was suggested by T. S. Eliot, a questing American refugee from American civilization:

> We shall not cease from exploration
> And the end of all our exploring
> Will be to arrive where we started
> And know the place for the first time.

10/1/81

Abstract of "Space Industrialization, the American Economy and American Foreign Policy"

Bruce Friedman, Chairman
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The acceleration of the process of space industrialization offers new possibilities in the supply of products and services to the American people from the extra-terrestrial environment. The history of the Communications Satellite Corporation illustrated the benefits to be obtained from the utilization of the extra-terrestrial environment in the area of telecommunications and the impact of the establishment of a global communications satellite network upon the nations of Europe. Space industrialization is a route toward decreasing the dependence of the United States upon other nations for the basic requirements of a modern technological society. The extra-terrestrial environment is a major new physical frontier which can be a resource base to aid this nation in overcoming the difficulties it is encountering in the current Kondratieff upswing. There are some analogies between the development of the space transportation system and space industrialization, and the relationship between the growth of the railroads and the development of the American West.

Space Industrialization, the American Economy, and American Foreign Policy

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Space industrialization(1),(2) is the process of developing the extra-terrestrial environment so as to provide increasing benefits in terms of products and services for the people of the world. The emphasis in this discussion is on the benefits to be accrued by the people of the United States of America. The products to be attained from the extra-terrestrial environment include raw materials, manufactured products, and energy. Space industrialization per se is the beginning of the process of extending the domain of humanity into the region beyond the atmosphere of the planet Earth. This extension will be both qualitatively and quantitatively different from the spread, growth, and development of humanity upon the face of this planet. Space industrialization is oriented toward aiding these dwellers upon an essentially two-dimensional surface. This orientation will tend to dwindle as time goes by as the growth of humanity into the outside universe proceeds on its course. However, this discussion deals only with the initial phase of this extension, namely, space industrialization.

The concept of space industrialization has also been called the third industrial revolution.(3) The first industrial revolution was that which commenced in Great Britain in the eighteenth century with the introduction of the steam engine and the rise of factory work. The second industrial revolution started after World War II with the development of solid state electronic devices and the beginnings of computers and automation. The depiction of space industrialization as a third industrial revolution following in the footsteps of the first two revolutions is, however, a misleading depiction.

For example, to a large extent the commencement of the second revolution is the result of investments made in basic research of the American Telephone and Telegraph Company through its Bell Telephone Laboratories in the area of solid-state physics. The first revolution was set in motion through the efforts of such individuals as James Watt and Simon Newcomb. The extra-terrestrial environment is the largest resource base now accessible to humanity. Barring any radical breakthroughs, the expeditious development of this environment is beyond the grasp of the private sector of the American economy, except in a secondary manner, within the immediate future. The primary mode of development must come through the action and funding of the government of the United States. This federal government in its actions represents the will of the people of America. Consequently, this primary federal role accounts for the emphasis in the definition of space industrialization that the process is oriented toward bringing its benefits to the people of the United States as a whole and not to any special portion of those people.

At this point in time the question is not whether or not to commence the process of space industrialization. This question has already been answered. The establishment of the Communications Satellite Corporation (Comsat)(4) by the federal government in 1962 marks the beginning of space industrialization. The question now is whether or not to greatly accelerate the pace of space industrialization already begun. The answer to this question is a firm "yes". The reasons for this answer for the United States are clear and are becoming increasingly clearer with the passage of time.

Coincidentally with the development of American capability to utilize the extra-terrestrial environment, this nation encountered a period of extra-ordinary difficulties. In terms of the resource base available to the nation, the most severe problem currently being encountered is the problem of securing energy sources in order to maintain and to continue the growth of the American society and economy. In turn, the state of the nation and of its economy are strong determinants in American foreign policy. To a large extent other nations, friendly, inimical, or indifferent to the interests of the United States, base their outlook and actions with regard to America upon the state of the health of the American society and economy. Conversely, the role which this nation perceives itself playing in the world community, that is, its foreign policy, is considerably determined by its collective societal outlook on life within that community, its assessment of its own societal strength, and the health of the national economy. The acceleration of the process of space industrialization offers possibilities in terms of ameliorating the energy difficulties of the United States and, more significantly, providing for long-term resource developments which would render the United States increasingly independent of other nations for the basic raw materials, products, and services required for the dynamic continuance of a technological society. Some of these developments can already be foreseen. Yet others will be discovered as space industrialization proceeds to unfold. Because of the nature and complexity of scientific and technological developments, some possible benefits expected to materialize from space industrialization endeavours may not be required because other routes toward obtaining these benefits may have rendered the extra-terrestrial approaches obsolete. Nevertheless, it is assured that the extra-terrestrial environment will provide an increase in the national resource base of a magnitude and uniqueness which cannot be even rivaled by any other possible resource base, such as, for example, the terrestrial oceans.

The point has been raised in the public dialogue over the dependence of the United States on petroleum from foreign sources that this state of affairs may be desirable. The argument is that this dependence leads to an increased interaction between the exporters and the importers of this petroleum in such a manner as to add to the stability of the world community and hence further the cause of world peace. This argument is fallacious unethical, and immoral. The United States of America has been thought of as a new Israel in the sense that the young nation founded on the North American continent, in the eighteenth century, is another Promised Land and whose basic principles are the same principles that guided the ancient Israel of the Bible. The United States is based upon the fundmental tenets of Judaism and Christianity. With regard to the relationship between the United States and the Organization of Petroleum Exporting Countries (OPEC), the United States is rendered vulnerable to extortion and blackmail in the determination of American foreign policy towards Israel because of the attitudes of some OPEC members. It is not fair, moral, or ethical to ask the American citizen to make a choice which amounts to determining if Arab petroleum is thicker than the Judaeo-Christian tradition. It is demeaning for the United States to have a foreign policy which could be affected by a weak position in its supply of petroleum. Such a weak position if it were to be indefinitely prolonged could actually lead to such instability on the international scene as to lead to war. It is conceivable that a sufficiently harassed United States would seize and garrison its Mideast oil supplies. Such a situation could lead to a confrontation between America and the Soviet Union.

Even if the United States were dependent upon basically benevolent nations, not having their own axes to grind, for petroleum, this position of dependence would still be basically unhealthy. When nations can take care of their basic needs without even the potential threat of extortion and blackmail, international relationships and trade can be carried out on a higher level of exchanging ideas and the manufactured products of technology and science. An atmosphere of fear and trepidation is not conducive to the improvement of international relations. Those who advocate a course that will not lead to American energy independence are seeking an easier and less effortful course for this nation because they feel that the course of energy independence demands too much of American society. They are looking for the lazy way out of the situation. In real life terms, it is not unusual for the lazy way out to turn out to be a course of disastrous consequences.

An increase in energy and other resources means an increase in the options of action and freedom available to the individual and to the society to which the individual belongs. Restriction of the resources available and hesitation in the development of new resource bases are harmful in the long term not only for the United States but for the entire global community. Life in a world with constantly dwindling resources would lead to growing strictures on the inhabitants of that world. Oil wars are just one of the numerous unpleasant consequences that could arise from resource limitations.

It is possible that some individuals deny the necessity for increasing American resource development for ulterior reasons. These people have an anti-technological bias.(5) They wish to live in a more simple pastoral type of society. This society would, so to speak, have to be in tune with nature. To keep in tune with nature would require a tightly regulated society. This regulation would be necessary to conserve and re-cycle the limited resources available to society. The utilization of technology except in certain special circumstances would be suppressed. Presumably, the rulers of this authoritarian regime would be the people who are now advocating the adoption of this route.

A relatively elite group of people go even further than advocating a return to a pastoral society. This elite feels that even if the energy and resource base can be expanded on a routine and continuing basis that this expansion must not be allowed to occur because humanity does not deserve this expansion.(5) This argument is very similar to the concept of original sin and that humanity must suffer until the race is perfected.

The population of a pastoral America would be much smaller than the country now supports. There would be no complex transportation network to tie communities together. There would be no industrial-agricultural system existing which could support a population of the size of that currently supported by the United States. The reduction in population if the pastoralists attained power in this nation could occur rapidly.

The pastoralists are a segment of the intellectual world which world has come to believe in a limit to the growth(6) of modern technological society. The limits to growth proponents believe that society is a closed system and this society cannot receive any new inputs external to it. The concept of space industrialization provides the intellectual world with the antithesis to the limits of growth argument. At various times in the past, society has seemingly arrived at a limit to further growth. However, human ingenuity has always shown ways to transcend these limits. Space industrialization is simply the most recent means of removing limits to growth. Indeed, the potential resource base that is perceived in the extra-terrestrial environment is many orders of magnitude greater than that has been obtained from present and earlier resource bases.

W. W. Rostow(6) is the economist who has seen most clearly the relationship between the development of resource bases and the transcending of limits to growth. He has also demonstrated how this relationship has been a primary causal factor in the development of the modern American society and its economic system. His approach is based upon an analysis of a long-term periodic phenomenon operating within the American economy and known as the Kondratieff cycle. This phenomenon derives its name from the Russian economist who first noted its existence.

The analysis of Rostow(6) is undertaken on a more basic level than that of his fellow economists who are more in the headlines nowadays. He deals in basic factors such as energy, natural resources, technology, and innovation. He does not become obsessed with such secondary issues as fiscal and monetary policy. This concentration on fundamentals allows him to chart an optimistic and realistic course for the American economy. An aggressive acceleration of the process of space industrialization falls naturally into the framework he prescribes for the maintenance of a dynamic American economy. In the course of his analysis, it becomes clear that he is more of a "supply-side" economist, to use popular phraesology, than any of his colleagues.

In order to understand the approach of Rostow,(6) it is necessary to know what are the characteristics of a Kondratieff cycle. Kondratieff studied statistical data which included interest rates, prices, and wages. He noted cyclical effects in these data for the United States, Great Britain, and France. These cycles, he felt, were an inherent component of the capitalist system. Perhaps a more accurate way of stating the situation, would be to consider these cycles as reflecting the operations of some more fundamental cause or causes. It seemed as if capitalist economies have a tendency to oscillate about an equilibrium position. He was unable to present an explanation for his observations. These observations led him into difficulties with the authorities in the Soviet Union because these observations ran counter to Marxist dogma. Kondratieff originally noted two and a half cycles. Rostow(6) has done further demarcating of these cycles and concludes that the United States is now in the midst of the fifth cycle. Rostow analyzes these cycles by considering the prices of food and raw materials relative to manufactured products of industry. These prices are a reflection of the abundance or scarcity of food and raw materials. The basic assumption of Rostow(6) is that the operation of Kondratieff cycles is determined by this abundance or scarcity.

The upswing of the first of the five Kondratieff cycles extended from 1790 to 1815.(6) During this cycle Great Britain shifted from having a surplus of food to being an importer of Eastern European grain as a consequence of a rising British population. The relative prices of food and raw materials in Britain rose at the beginning of this cycle. Wars produce distortions in Kondratieff cycles and in this period from 1790 to 1815 the wars of the French Revolution and the Napoleonic era occurred. These wars shifted resources within the British economy so that the rate at which cotton textiles manufactures production grew was decreased. Concurrently, the wars increased resources devoted to the British iron industry, thus accelerating that development. In America, prosperity increased because prices for American food and raw materials exports grew as a result of the demands of the warring European nations.

The downswing of the first cycle occurred from 1815 to 1848, when peace in Europe and the return to the normal import patterns for grain sent from Eastern Europe to Western Europe and Britain resulted in a drop in agricultural products and raw materials prices.(6) When the cotton industry expanded in Western Europe, Britain, and the United States, prices of cotton products were driven higher. This price increase provided capital for expansion of transportation facilities in those nations. At the beginning of the downswing, the growth of cotton textiles manufactured products, steamboat river transportation, and steam engine powered industry had been high because of the low cost of agricultural products and raw materials. After the brief period of price increase because of the cotton manufactures expansion, prices for agricultural products and raw materials again dropped and allowed an increase in the growth of railroads and industry both in Europe and America. However, toward the end of the downswing there were indications of an imbalance between food and population developing, as was shown by the situation with respect to the potato crop failures.

The upswing of the second cycle extended from 1848 to 1873.(6) The dichotomy between population and food supply led to a short period of accelerated price increases for grain. Cotton followed the same price route a decade after cotton. The grain price increase provided capital for railroad expansion. This railroad expansion opened up new land for grain production. This upswing was distorted by a number of small wars and by gold mining. The discovery of gold in California was another reason for the flow of capital into railroad expansion. Toward the end of this upswing, coal prices in Britain rose sharply because the available mining capacity was not keeping pace with the local and foreign requirements. By expanding the available mines, prices for coal were subsequently lowered.

The downswing of the second cycle stretched from 1873 to 1896.(6) Because of an abundance of agricultural products and raw materials accompanied with the resultant drop in their prices, there was a great expansion of industry. In the United States, railroad expansion was more dynamic relatively late into the downswing as compared to the situation in most of the other advanced industrial countries because this additional expansion was required to more fully realize the earlier American railroad development. This railroad expansion gave rise to an increase in the supply of steel and a lowering of the price of steel. Steel utilization was thus greatly facilitated with regard to buildings, bridges, ships, machine tools, and steam engines. Electricity and new forms of chemicals began to find practical applications. Toward the end of this downswing, the American capacity to export wheat decreased as a result of the increase in the American population and the increasing proportion of that population moving into cities.

The pattern continues in the upswing of the third cycle.(6) Extending from 1896 to 1920, this upswing was characterized by a relative deficit in the availability of agricultural products and raw materials. As the result of the expenditure of large amounts of capital to correct this imbalance, the United States, Australia, Canada, and Russia quickly expanded their industrial and agricultural bases. Expansion of the railroads had by now essentially attained a saturation point and the steel industry was decreasing its expansion rate. Along with this decrease in expansion rate, the productivity of the steel industry was decreasing. The decrease in expansion in the railroads and the steel industry was not completely compensated for by accelerated expansion in the electrical and chemical industries and growth in the utilization of the internal combustion engine. World War I was a distorting factor in this upswing in that, for example, this war increased the demand for steel which demand would not have existed without the war.

Lasting only from 1920 to 1933, the third cycle downswing was relatively short compared to the previous downswings.(6) With the coming of peace, there was a marked drop in the prices of agricultural products and raw materials. Unlike the previous downswings, the price drop by itself did not produce a sufficient acceleration of the newer segments of the economy, such as the electrical industry, so as to avoid an overall stunting in the growth of the economies of the more industrialized nations.

From 1933 to 1951, the forth cycle upswing found prices of agricultural products and raw materials again rising.(6) World War II was the major distortion factor during this period.

The forth cycle downswing extending from 1951 to 1972 was dissimilar to the third cycle downswing, although once more energy, foodstuffs, and raw materials were relatively inexpensive.(6) An interesting point about this period is that numbers of the less developed country (LDC) group of nations who depended upon exports of their raw materials, crude oil, and foodstuffs for income for their own development did not suffer from these low prices but continued to develop because of the strong markets provided by the advanced industrialized nations. These industrialized nations through their governments provided further investment capital to the LDC group. In the United States, economic growth shifted from the automobile industry and durable goods production to the service sectors of travel, education, and health. In the second half of the downswing, an imbalance was produced by a swift increase in world energy and food needs. This pushed prices higher. Rostow(6) feels that the culmination of this downswing in the United States can be interpreted as this nation having reached the limits of its then existing agricultural, oil, and gas frontiers.

The United States and the other capitalistic nations are now in the midst of the upswing of the fifth Kondratieff cycle which upswing began in 1972.(6) In the following year, OPEC quadrupled the price of the oil which its member nations put on the market. This price increase and subsequent OPEC price increases have played a major role in shifting the international balance of payments of the advanced industrialized nations. The energy price rise had an adverse effect upon the energy-intensive components of the American economy, such as the automobile industry, durable consumers products, and the chemical industry. The other industrialized nations have been similarly affected. The difficulties of the industrialized nations have in turn had a negative impact upon the members of the LDC group.

It is tempting to conjecture that phenomena analogous to Kondratieff cycles occurred in history before the advent of industrialization and that the dynamics of such cycles would be similar to those dynamics proposed by Rostow(6) for the Kondratieff cycles. Long-term cycles could occur even in barter economies. Any type of society must have access to foodstuffs and raw materials simply in order to survive. The degree of accessibility, as a function of both space and time of these factors would affect the rate of growth or disintegration and produce fluctuations of the geographical extent of the society. Any society without a central regulating mechanism could tend to oscillate about an equilibrium point as access to raw materials, energy sources, and foodstuffs waxed and waned.

In any case, the analysis of Rostow(6) with regard to the Kondratieff cycles leads him to enunciate a policy for implementation and action. Since a scarcity of energy, agricultural products, and raw materials drives their prices up relative to manufactures, in order to drive their prices down it is necessary to make investments in terms of capital, science, technology, and industry to remove this scarcity and change it to an abundance. Rostow(6) does not directly address the possibility that this may require a course of deficit spending in either or both the private and public sectors of the economy in the short-term in order to secure the abundance in the long term. The willingness to incur such short-term deficits is a function of the severity of the consequences of not incurring such deficits. In this fifth Kondratieff upswing it is becoming increasingly clear to many people that not incurring any unavoidable deficits is a path that can have serious negative and even disastrous consequences. The necessity for making appropriate rectifying investment is that first policy implication drawn by Rostow(6)..

. However, Rostow(6) makes a serious omission in working out some of the connotations of his first policy implication. During the first four Kondratieff cycles there were always new major physical frontiers waiting to be developed in order to secure their natural resources. He believes that this is no longer true during the current cycle. Certainly, he states, there are areas such as the oceans which could provide minerals but there are no longer great territorial areas available to the global economy in order to counter-balance a spreading process of industrialization. In this belief of the lack of a new major physical frontier from which plentiful resources can be secured, he is completely wrong. Since he does not even consider the process of space industrialization and consequently attempt to ascertain the merits of developing the extra-terrestrial environment, it may be that he is conditioned to thinking only in terms of a frontier lying on the two dimensional surface of the earth. By the surface of the earth is meant those few tens of miles of crust which overlay the inner material of this planet. It does require a conceptual shift on the part of the human mind to allow the incorporation of the ideas of indefinite travel along a third dimension perpendicular to the surface of the earth and the infinity of surfaces concentric with the terrestrial surface.

Rostow$^{(6)}$ is not correct in believing that the development of new technolgoies will take the place of opening up a great new physical frontier. The development of new technologies is always desirable and in general even necessary to allow for the most efficient utilization and conservation of the natural resource base available to the human race at any given point in time. He is making a seriously incomplete conclusion when he states that new technology development would permit modern industrial society to become increasingly modernized and continue its expansion. In the short term he may be right. However, implicit in his belief is the view that the global industrial society is a closed system which does not now and will not in the future receive any significant inputs external to the surface of the earth beyond the atmosphere.

Consider a particular raw material, a metallic element, within a closed world industrial system. By the definition of a closed system, the total amount of that raw material both actually and potentially accessible to that system can be no greater than the amount of the material physically existing within the system. Suppose that there are a number of uses for that particular raw material. All of these uses are completing with each other for the raw material since an increase in the demand for the material by one use leaves less material to be shared by the remaining uses.

Suppose now it is discovered that in one application the original raw material, labelled A, can be replaced by another raw material, labelled B. Material B is cheaper, more widespread, and more accessible than material A. Unlike material A which is preferentially located in some countries with those countries having most of the material and the highest quality ores, material B is much more evenly distributed in high grade ores so that no nation or group of nations can control the availability and the price of material B. This sounds like a considerable improvement over the original situation. Material B is now increasingly utilized for material A in that application.

Time goes by. The demand for material B rises as it replaces material A in the application which is specified to be the manufacture of an alloy. After a while, the demand for the alloy itself increases. This further increases the demand for material B. Depending upon the demand in the specific nations for material B and the alloy, some nations begin to exhaust their domestic supplies of readily accessible material B before other nations approach the same situation. At this point, it is time to start looking for a substitute for material B.

Thus, even with the most ingenious utilization of science and technology a closed industrial system will reach basic limits that cannot be transcended. Even before those basic limits are reached, increasing environmental, energy, raw materials, economic, and political difficulties will materialize. Apparently, the only way to completely eliminate limits to growth is to attain the ability to make something from nothing. This ability would require the existence of science and technology incalculably beyond anything now within the grasp of mankind. Barring the existence of such science and technology and neglecting the potential of the process of space industrialization, sooner or later the global industrial society will have to stabilize itself at some optimal equilibrium level which level would probably be unable to sustain itself at a given fixed point for any significant length of time because of the complexity of the system required to maintain that stability. The breakdown of the stability maintenance mechanism would lead to the deterioration of the global industrial society. Intensified research and development can, consequently, only go just so far in sustaining the growth of industrial society in the absence of an accelerated program to widen the limits by developing the more than major new physical frontier of the extra-terrestrial environment.

In order to more specifically illustrate the limits difficulty to be dealt with in the absence of the new physical frontier consider the example of the metal aluminum and its alloys.(7) The most common alloying element used with aluminum has been copper. There are basically six types of aluminum-copper alloys. Three of the six types are cast alloys. The five percent copper content aluminum-copper cast alloys contain smaller quantities of silicon and magnesium. The seven to eight percent copper content aluminum-copper cast alloys contain substantial quantities of iron and silicon and lesser quantities of, for example, manganese, chromium, zinc, and tin. The ten to fourteen percent copper content aluminum-copper cast alloys contain 0.10 to 0.30 percent of magnesium, less than 1.5 percent of iron, less than 5.0 percent of silicon and lesser quantities of nickel, manganese, and chromium. The fourth type of aluminum-copper alloy is of the wrought variety. The wrought alloys contain five to six percent copper with lesser quantities of manganese, zirconium, silicon, vanadium, cadmium, lithium, tin, and bismuth being possible additions and if these alloys have further additions of lead, bismuth, and/or cadmium they are easier to machine. The fifth type of aluminum-copper alloys comprises the durals which are characterized by containing 4.0 to 4.5 percent copper, 0.5 to 1.5 percent magnesium, and 0.5 to 1.0 percent manganese with possible silicon supplements. The sixth type of aluminum copper alloys is characterized by the further addition of nickel. There are two subgroups of the aluminum-copper-nickel alloys. The first subgroup is the Y alloys containing 4.0 percent copper, 2.0 percent nickel, and 1.5 percent magnesium. The second subgroup comprises the Hyduminiums having a lower copper content than the Y alloys and having iron substituted for some of the nickel.

Bauxite is the primary mineral ore source of the metal aluminum.(8),(9) Bauxite, however, has other uses. It is used to manufacture synthetic abrasives, certain chemicals and refractories, and it can also supply titanium and thorium as by-products of ore processing. In the fifteen year period after World War II from 1945 to 1959, about 84 percent of the bauxite production of the world came from France (9.5 percent of global production), the Soviet Union (10.2 percent), the United States (11.5 percent), British Guiana (15.1 percent), Jamaica (17.8 percent), and Surinam (20.1 percent). In the year 1962 by itself, the same six countries secured only about 69 percent of the global production of bauxite. Also, the fractions of bauxite produced by the same six nations had shifted significantly as compared to that post-war period, the result being France (7.0 percent), the Soviet Union (13.3 percent), the United States (4.5 percent), British Guiana (8.9 percent), Jamaica (24.7 percent), and Surinam (10.6 percent). Clearly, while the Soviet Union had made some increase in its relative production of bauxite, the United States position had already severely deteriorated. In the period from 1973 to 1977, the United States global share continued to drop to 2 percent. Further, the three leading producers, Surinam, Jamaica, and British Guiana are still considered to be members of the LDC group of nations. To put the situation into even more proper perspective, the number of pounds of aluminum consumed by each person in the United States per year have steadily risen since the end of World War II, so that in 1948 the consumption(9) was 10.9 pounds per person per year (PPY), in 1958 it was 25.2 PPY, in 1968 it was 46.9 PPY, and in 1978 it was 54.9 PPY. The United States has become almost totally dependent upon other nations for bauxite.

From 1953 to 1957, the average yearly production of bauxite was 398,000 metric tons, while from 1973 to 1977, it was still about the same, 415,000 metric tons. From 1953 to 1957, domestic American production constituted 25 percent of the American market for bauxite on an average yearly basis, while from 1973 to 1977 this figure dropped to 11 percent.. It is highly unlikely that the United States can do anything in the immediate future to improve this situation since as of 1976 it was estimated to have only 10,000,000 standard tons of aluminum ores in reseverve(9) as compared to the global figure of 8,810,000,000 standard tons, unless a substitute for aluminum were to be decided upon and found in more plentiful quantities upon United States territory. Possibly securing some aluminum ore from the oceans might be of aid within a decade.

The extra-terrestrial environment could possibly be an eventual source of aluminum. One source of information now available concerning minerals in the extra-terrestrial environment is the meterorites(10) that fall upon the earth. The four main groups of meteorites are chondrites, achondrites, stony-irons, and irons. The chondrites are dominant, constituting over 80 percent of the meteor falls. The type III carbonaceous chondrites have the highest aluminum concentration by weight as compared to the other chrondrites with this content varying from about 1.3 percent to 1.6 percent. The highest concentration of aluminum in all meteor groups is found in two types of calcium-rich achondrites. These are the howardites with a concentration ranging from 2.7 percent to 5.0 percent and the eucrites with a concentration ranging from 6.1 percent to 8.3 percent. Another limited source of information concerning minerals available from the extra-terrestrial environment is the samples returned from the moon(11) by manned and unmanned missions of the United States and the Soviet Union to that body. In Luna 16 aluminous mare basalt samples, the aluminum oxide content is found to vary from 11 percent to 20 percent by weight.

The question as to how soon aluminum from beyond the earth could be a significant factor in the economy of the United States can best be decided in the course of an accelerated process of space industrialization. There are many steps to be undertaken before the first commercial delivery of extra-terrestrial aluminum could be made. The pace of space industrialization must be quickened now while the United States still has the industrial, technological, and scientific base to do so. With such a quickening, commercialization of extra-terrestrial mining including that of aluminum ores could be a commerical reality within several decades.

In the case of copper(8),(9) 82 percent of the global copper production from 1945 to 1959 came from the combined efforts of the United States (29.6 percent), Chile (14.9 percent), Zambia (11.6 percent), the Soviet Union (10.0 percent), Canada (9.0 percent), and the Republic of the Congo (7.1 percent). In 1962, the corresponding figures were 24.3 percent, 12.8 percent, 12.2 percent, 13.8 percent, 9.2 percent, and 6.4 percent, respectively, the combined total being about 79 percent. In 1976, the copper ore reserves(9) of the United States were estimated to be 93,000,000 standard tons as compared to 503,000,000 standard tons for the entire world. The situation with respect to copper ores is much better for the United States than it is for aluminum ores as compared to the rest of the world. It is interesting to note that although the global reserves of aluminum ore are much greater than the reserves of copper ore, the United States is much more self-reliant with respect to copper than it is for aluminum. It is this sort of data that shows that the total global amount of any particular mineral resource could be a secondary consideration to the American economy and to American foreign policy as compared to what nations are significant sources of supplies of the resource. The relationship of the United States with nations providing much of its mineral ores is a variable. For example, the Soviet Union clearly cannot be relied upon as a source because of its often expansionist and aggressive viewpoint. The members of the LDC group of nations are striving to duplicate in the area of non-fuel minerals what OPEC has been doing with regard to petroleum. This attiture of the LDC group has been demonstrated already in the United Nations negotiations concerning the law of the sea and in the colloquially named Moon Treaty(12) prepared for signing also as a result of United Nations negotiations. The LDC group is apparently operating under a policy which can be considered a logical corollary to a belief in the comentional limits to growth. This policy known as the New International Economic Order (NIEO) is much more concerned with re-distributing the wealth of the world than with generating new wealth.(9) The NIEO policy is a non-constructive route.

Again, limited data about the accessibility of copper in the extra-terrestrial environment is obtained from analyses of meteorites.(10) Copper has been found to exist in trace amounts only ranging from 3.0×10^{-6} grams/gram in howardites to 190×10^{-6} grams/gram in type I enstatite chondrites. This low concentration should not be taken in a discouraging manner. Within the current state of scientific knowledge, it has been ascertained that the universe is basically the same everywhere, behaving the same way under the same physical laws and being composed of the same chemical elements. The moon, the asteroids, and other material in the cosmic neighborhood of the earth, should have rich copper concentrations just the same as does the earth. It is a matter of discovering those concentrations. The proper course of action to initiate now is to have an intensive program to survey the neighboring cosmic matter and prospect for mineral wealth with the use of both remote-sensing techniques and the use of space vehicle probes.(12),(13) This exploration would involve the use of both manned and unmanned spacecraft. In this manner, as the process of space industrialization proceeds to successively more sophisticated levels, when the time arrives for the first attempt at actual extra-terrestrial mining activities the data will be at hand to more securely attain profitable successes as soon as possible.

What, in general, is meant by the phase "natural resources of the extra-terrestrial environment"? These resources include the major planets, their natural satellites, and the other material objects of the solar system. The sun and its outpouring of radiation is another resource. Space itself is a resource with its high vacuum and the ability to have objects within it in a state of freefall.

The energy radiated by the sun is more accesible beyond the atmosphere of the earth than it is at the surface of the earth. This energy could be sent down to the surface of the earth more copiously than is now done by nature. One possibility is the satellite solar power station which would catch sunlight, convert it into microwaves or laser radiation, and send the converted radiation down to the earth where it would be converted further into electricity.(1),(2) Another more simple way of enhancing the reception of solar energy at the surface of the earth would be to use giant orbital mirrors.(1),(2) Additional sunlight does not have to be brought to earth in order to be used. The earliest uses of solar energy in space industrialization have been to power the various types of artificial satellites and space probes. In the long term, that is, as the centuries unroll, it may turn out that more solar energy may be used by the various processes comprising space industrialization in the extra-terrestrial environment itself than is delivered to the earth by power satellites and mirrors. After all, the closer to the sun an activity is brought the more intense is the radiation that can be captured. If the distance to the sun is halved, the intensity of the solar radiation is increased by a factor of four. The sun itself is a natural thermonuclear fusion reactor converting mass into energy and radiating the energy away at the rate of 3.8×10^{33} ergs/second.(14)

In the coming several decades, the basic sources of material natural resources will be the moon of our planet, the natural satellites of the planets closest to the earth, the asteroids, and smaller objects, such as, meteoroids. The moon is the body with the largest mass that is closest to the earth of all of these objects. It is most likely that lunar material would be used for space industrialization purposes before material from any of these other bodies. The earliest use of lunar material would probably be for construction purposes in the extra-terrestrial environment itself after refining and fabrication processes were applied and as raw material for such devices as solar cells to be used in both the terrestrial and extra-terrestrial environments. Because of the relatively high intensity gravitational field of the moon it is unlikely that lunar material although processed beyond the earth could be used on this planet in applications that would require large masses of the final product to be delivered to the earth. Selected asteroids appear to be more probable candidates to supply raw material whose refined form would be desired in large masses on the earth.(13) Because of the availability of solar energy in space and its increase in intensity as the sun is approached, it would seem to be most sensible to perform as much as possible of the processing of extra-terrestrial raw materials in the extra-terrestrial environment itself at or within the orbit of the earth about the sun.

In addition to his policy implication concerning investment, Rostow(6) draws a second policy implication. This second implication is that governments must take a greater role in providing for the required investments than they have played in the past. There is no question but that this is a true statement in general, as has already been noted earlier in this discussion with regard to space industrialization. Crude analogies have already been drawn between the construction of the railroads in the United States and the research and development now being performed to get the space shuttle on the tracks.(15) The research and development work preliminary to building the railroads, such as the work of James Watt on the steam engine, did not come from any governments. The actual construction of the American railroads was financed by both public and private capital. It is extremely unlikely that the research and development that has been done and will be done on the space shuttle could to any measurable intent be financed by private capital because of the complexity and magnitude of the task. Even after the space shuttle is out of the development phase, it will probably be a good number of years before one or more shuttles is purchased or even leased by a corporation or a group of corporations. Yet, the space shuttles are only a small part of the entire space transportation system (STS) required in order to realize the complete potential of space industrialization in the coming decades.(1),(2)

The situation of the building of railroads and the coming construction of the STS are basically different in terms of raw materials and foodstuffs access.(16),(17) Wheat was already being grown and the trains brought this wheat to market. In turn, this easier access to the market, spurred on further railroad construction. The systems involved in this synergistic relationship were much less complicated than will be the case of the STS and its relationship to raw materials, energy, products, and to its market. The situation of the railroads with respect to mineral wealth was similar to the position of the railroads with respect to the wheat market. Private capital was, at least partly, able to carry the load of financing railroad growth because the time to attain a return on investment was relatively much shorter, in general, for the railroads as compared to the STS situation. The uncertainties and risks involved as perceived by the sources of private capital in the case of American railroad expansion in the nineteenth century were considerably less than in the case of the STS and private capital nowadays. There is nothing like the equivalent of the wheat situation in the nineteenth century to spur capital investment from the private side of the economy in space industrialization. Another significant factor is perhaps that modern-day capitalists are not as daring and venturesome as their nineteenth century counterparts, such as, for example, Jay Gould.(16),(17)

There are yet other basic differences between the growth of the American railroads and their relationship to American industry, society, and economy and the corresponding situation with regard to the STS and space industrialization. It is difficult to analyze the differences exactly at this point in time because although the story of the railroads and their impact in American history is already a matter of record, the story of the STS and space industrialization has yet to be written. The railroad story is far more constrained and self-limiting in terms of space and time as compared to the space industrialization story which latter is a relatively open-ended one. With space industrialization, the story will extend eventually over the entire solar system over a span of centuries. There is an even more fundamental difference which is understood by the studies of American railroads by R. W. Fogel.(17)

Fogel(17) has critically examined the question as to just how essential the railroads were to American economic growth. Utilizing a theoretical and analytical approach, he comes to the interesting conclusion that if the railroads had never existed, alternative means of transport would have been developed so that economic growth would have continued. The railroads were a result of previous discoveries and inventions. These discoveries and inventions were also the basic for economic growth. One of the conditions that had to be satisfied for the continuation of American economic growth was that a cheap method of transportation within the country and from coast to coast was required. If the railroads had not been built, then some other form of sophisticated relatively high-speed transportation, possibly by canal, would have arisen.

The situation nowadays with respect to the STS is different. If the STS is not developed, then there will be no way to attain extra-terrestrial resources in a cost-effective manner, barring a totally unforeseen scientific discovery.

It has been noted herein that private investment played a major role in railroad development,(16),(17) while the current STS development is entirely federal government investment. It should be noted that federal, state, and local investments were also a major factor in the growth of the railroads. This is a reflection of the view of those times that there were both public and private roles to be filled in providing for this growth. The United States Congress voted to give over 100,000,000 acres of public domain land to railroad promoters between 1850 and 1872. Approximately thirty percent of the total capital investment in the railroads or about 280,000,000 dollars in cash or credit was provided by state and local governments in the period before the Civil War.(16),(17)

While it is unlikely that private enterprise can be encouraged to make any significant investments in the STS itself in the near future, there are steps that can be taken to encourage more investment by the private investment sector in the wheatfields of space industrialization(15), so to speak. The aim is to encourage companies to seek to develop extra-terrestrial products and processes in the early years of the use of the space shuttle from which products and proccesses the companies could obtain relatively near term profits. One possibility is to establish a federal trust fund from which companies could draw upon in order to perform the research and development phase .(18) If a commercially viable extra-terrestrial product or process were attained, the company would then repay the trust fund with appropriate interest. If the company failed in its attempt, it would provide a complete report and analysis of its project to the managers of the trust fund. This report and analysis would be in the public domain so that other companies trying to develop extra-terrestrial products and processes could use this information in their projects. The trust fund approach would be most appropriate for smaller companies.

For larger companies, the accelerated depreciation route would be more applicable. The accelerated depreciation rate would be proportional to the research and development funding that the company invests. Accelerated depreciation would also apply to when the product or process were marketed on a commerical scale. In cases where the heaviest investments were undertaken, instant or even augmented depreciation could be taken. With augmented depreciation,(19) a firm could write off more than it invests. Firms involved with satellite telecommunications, such as Comsat and Western Union, that have their rates to the users of their services regulated by the Federal Communications Commission could have their accelerated depreciation rates made proportional both to the size of their rate reductions and their research and development investments. If their rates remained the same or decreased, the depreciation rate would remain unchanged. Tax credits are another way of spurring investment.

Another approach would be to use insurance to act as a cushion against extra-terrestrial product and process research and development failures. The insurance could be supplied by the federal government, a group of private insurance companies, or by a combination of public and private insurance. Communications satellites are already covered by private insurance.

Addressing the question of federal government regulation of the private sector and a relaxation of anti-trust laws would encourage group efforts that no one company would try on its own. A consortum comprised of several companies coupled with the intelligent use of tax credits and accelerated depreciation, in addition to undertaking space industrialization projects, might even be able to add components to the STS itself. Combinations of companies could be further increased by allowing a company investing a certain amount of funding in a given project, a greater tax credit and accelerated depreciation if it makes that investment as a member of a consortium as opposed to making that same investment while it only is on its own. For example, suppose Comsat has some of the expertise and the desire to develop a re-usable solar-electric orbital transfer vehicle. It believes that such a vehicle could profitably transfer government and private payloads from low earth orbit to geosynchronous orbits and beyond. The research and development investment required for this effort and the construction of a commercial fleet of such orbital transfer craft is far beyond the capabilities of Comsat by itself. It then organizes a consortium with several other companies, such as, for example, Westinghouse, General Electric, Exxon, and Mobil, to successfully carry on the program and deploy the vehicles. The federal government could aid the consortium by giving special low rates to the consortium foruse of the space shuttle and other government facilities.

However, no matter what amount of economic organizing ingenuity is utilized, it still is highly likely that the federal government will have to play the dominant role in space industrialization in the coming several decades. The history of space industrialization, modest as it has been to date, is indicative of the situation.

The launch vehicles developed and produced to date have all been completely funded by the federal government. The relatively miniscule contributions by McDonnell-Douglas in making improvements to the Delta launch vehicle and in developing a Payload Assist Module (PAM) to be used in conjunction with the space shuttle are simply the tiny exceptions that prove the general rule. The original Delta launch vehicle was originally the result of combining the Thor ballistic missile and the Vanguard second stage and then a solid fuel rocket for a third stage. The Delta launch vehicle has been utilized many times to launch space probes, scientific satellites, weather satellites, and communications satellites for government and for industry. The Atlas-Centaur launch vehicle is similar in that the Atlas first stage was originally developed as an intercontinental ballistic missile. The Centaur upper stage was specifically developed by the government for just that purpose of being an upper stage. It is anticipated that the Centaur will be modified for use by the space shuttle to send satellites into higher orbits and to launch space probes. The original government investment in developing and producing launch vehicles aside from the space shuttle represents a multi-billion dollar investment. Since the advent of commercial communications satellites, companies have paid the government for the launch vehicles and reimbursed it for launch operations services, but this hardly suffices to recompense the government for its investment to date. Building launch vehicles and supplying the services for launching them is a United States government monopoly operation, and will remain so for at least the next ten to twenty years.

By the time Comsat was founded, the United States through the instrumentality of the National Aeronautic and Space Administration (NAS) and the predecessor to NASA, the National Advisory Committee for Aeronautics (NACA), had already made significant investments which were a major factor in assuring the success of Comsat. On the private side of the economy, during the same period of time, the investment was essentially zero.

NASA began operations on October 1, 1958, more than a year after the first sputnik was orbited.(20) It inherited NACA to act as its core. For the fiscal year (FY) 1958, the last year for the operation of NACA, the NACA had a budget of about $100,000,000. The budget of NASA rapidly climbed to 331,000,000 dollars in FY 1959, to 524,000,000 dollars in FY 1960, to 964,000,000 dollars in FY 1961, and to 1,825,000,000 dollars in FY 1962 From NACA, in 1958 NASA inherited five major installations, namely, Langley Research Center, Ames Research Center, Lewis Research Center, Flight Research Center, and Wallops Station whose plant costs estimates were 126,000,000 dollars, 87,000,000 dollars, 120,000,000 dollars, 17,000,000 dollars, and 4,000,000 dollars, respectively. NASA proceeded to build additional facilities of its own such as Goddard Space Flight Center in Maryland and the Kennedy Space Center in Florida in addition to further building up its inherited facilities. The space agency started out with a staff of 8,000 people from NACA, added on additional personnel and proceeded to contract out most NASA work to industry/ NASA developed its family of launch vehicles in addition to what it obtained from the U.S. Army and U.S. Air Force.

Through FY 1963, NASA already had made significant investments directly related to communications satellites.(20) In the area of space applications, the research and development direct obligations were 4,000,000 dollars in FY 1959, 8,000,000 dollars in FY 1960, 28,000,000 dollars in FY 1961, 75,000,000 dollars in FY 1962, and 93,000,000 dollars in FY 1964. In the area of space power and electric propulsion systems, the research and development direct obligations were 400,000 dollars in FY 1959, 1,000,000 dollars in FY 1960, 5,000,000 dollars in FY 1961, 27,000,000 dollars in FY 1962 and 40,000,000 dollars in FY 1963. In the area of research and development direct obligations for launch vehicle development, it is appropriate to examine the finanical situation beyond FY 1963. In this area, the obligations were 22,000,000 dollars in FY 1959, 51,000,000 dollars in FY 1960, 79,000,000 dollars in FY 1961, 82,000,000 dollars in FY 1962, 99,000,000 dollars in FY 1963, 108,000,000 dollars in FY 1964, 92,000,000 dollars in 1965, 52,000,000 dollars in FY 1966, 30,000,000 dollars in FY 1967, and 100,000 dollars in FY 1968. The research and development obligations in space applications included funding for the Echo, Relay, and Syncom communications satellites.(20)

About a week after the completion of an American manned space mission, hearings were held in the United States Senate on the legislation that would eventually establish Comsat.(21) Testimony was presented by representatives of a wide range of organizations, including the Department of Defense (DOD), NASA, the Antitrust and Monopoly Subcommittee of the Senate Judiciary Committee (AMSSJ), the American Telephone and Telegraph Company (AT&T) the Federal Communications Committee (FCC), Americans for Democratic Action (ADA), and the Radio Corporation of America (RCA). The hearings were held before the Senate Aeronautical and Space Sciences Committee (SASSC). The points of view and opinions presented at those hearings are directly pertinent to the situation of space industrialization today.(21).

The testimony of James E. Dingman, then executive vice president of AT&T, sheds some light on the private investment role in communications satellite technology at that time.(21) Dingman was speaking shortly before NASA orbited the AT&T communications satellite TELSTAR. The research and development cost plus the cost of the satellite itself and the associated ground facilities came to something over 25,000,000 dollars. This should be compared to the overall NASA and military investment in the several years before the hearing and in the several years after that hearing. AT&T was probably by far the largest corporate investor in developing communications satellites before the establishment of Comsat.

Joseph A. Beirne then president of the AFL-CIO union Communications Workers of America (CWA), testified as to the public and private investment aspects of the proposed legislation.(21) He approved of the provisions of the bill that allowed for widespread public ownership of the new corporation instead of allowing ownership only by the communications carriers, such as AT&T. An interesting aspect of the testimony of Beirne is the spirit of venturesomeness that he expresses which spirit was shared by other people who testified at these hearings. This spirit can be compared to the spirit of the government and private sectors of the economy in the days of the founding and growth of the American railroads.(16),(17) This spirit seems to have dwindled since the completion of the Project Apollo lunar landing program.

Senator Estes Kefauver of the AMSSJ testified with regard to possible monopolistic aspects of the proposed legislation.(21) He made a point of commenting that the federal government had the dominant role in the development of satellite communications. The senator noticed the relationship of a communications satellite network to American foreign policy. He was considerably aware as to how private enterprise even then in 1962 felt inadequate to completely carry the burden of developing an entire communications satellite system which system would include the development and production of launch vehicles. He quoted a figure of about twenty five billion dollars which the government had already invested before the hearing had been convened.

The passage of the legislation establishing Comsat and the signing of that legislation by President John F. Kennedy is one of the most farsighted and intelligent acts of the United States government and of the American people.(4) In the long term, as the years, the decades, and the centuries roll by, this accomplishment will be seen to be the most important deed of President Kennedy, transcending his initiation of the Apollo project and his accomplishments in the more mundane spheres of activity. It is generally agreed that Comsat has accomplished its goals in a shorter period of time than it was anticipated that it would at the time this corporation was established.

The original Comsat act states that it is the objective of the United States to establish by deeds of its own in conjunction and cooperation with other nations a global communications satellite system as quickly as possible.(4) Comsat is inextricably involved with American foreign policy because the legislation states that this network is to satisfy the needs of both the United States and the world community. This network is to foster the peace of the world and contribute to increased understanding between nations. Special emphasis is placed on providing services to the LDC group of nations. The private enterprise corporation known as Comsat is established to act as the instrumentality to accomplish these goals. Comsat is not to discriminate among any of the users of the system. It is to behave in a manner consistent with the anti-trust laws of the federal government and is to minimize competition as far as providing services and equipment which is used by the global network. Additionally, it is to stimulate competition while providing its services to the people of America and to the world community. The legislation does not exclude the use of the global satellite network for the supply of services to the United States and it allows for the establishment of additional communications satellite networks beyond Comsat. Thus, the Communications Satellite Act of 1962 (CSA62) is a delightful balancing act.(4)

The President of the United States, NASA, and the FCC are each allocated specific responsibilities in order to have CSA62 attain its purpose and objectives.(4) The responsibilities of the President include supporting the planning, development, and promotion of the American program for founding and operating the system and seeing that the relationships of Comsat with other nations and any international agencies are consistent with both the maintenance of the security of the United States and its foreign policy. NASA, among other responsibilities, is to serve as a technical advisor to the FCC, cooperate with Comsat in research and development to the extent that NASA feels is appropriate, and to supply launch and other services to the corporation on a basis of reimbursement. The responsibilities of the FCC include, among other responsibilities, insuring that Comsat acquires its facilities and equipment through competitive bidding as much as possible, that user rates are set for the corporation so that economies of operation are passed on to the users of the system, and having the power to authorize Comsat to issue stock beyond the initial issue.(4)

All of the members of the board of directors of Comsat are required to be citizens of the United States.(4) Three of these members are appointed by the President of the United States. Six of the board members are chosen by the communications common carriers that are stockholders in Comsat and the remaining six members are selected by the other stockholders in the corporation.(4) Currently, the corporation has no common carrier stockholders.(22)

Comsat and CSA69 have had at least one major impact upon American foreign policy in a way that was not foreseen by Congress and the President in

1962. The global communications satellite network during the Vietnam War gave the American public at home an intimate rendezvous with death. By bringing scenes from Vietnam on the home television screen within hours of their occurrence on the battlefield, the movement to stop the war received a continuous stream of audio-visual support. It is ironic that the most avid of the so-called radical pacifists of the Vietnam War era were also avidly anti-technological since the communications satellite network played so pivotal a role in spreading the news about the horrors of the war.

After the creation of Comsat, it started to negotiate with the nations of Europe to form an international communications satellite system.(22) The result was the signing of two interim agreements in 1964 creating the International Telecommunications Satellite Organization (Intelsat). Permanent agreements were set up for signing by 1971 and these agreements commenced acting in 1973. Under the permanent agreements, Comsat was given the position from 1973 to 1979 of being a contractor to provide management services. The agreement stated that in 1979, Intelsat was free to retain the services of Comsat or seek another source of such services. Actually, in 1978 the contract became strictly a technical services non-management agreement.

Intelsat is composed of four main components, the dominant one being the Assembly of Parties.(22) The other three components are the Meeting of Signatories, the Board of Governors, and an executive organization which is responsible to the Board. The Assembly comprises all of the parties signatory to the agreements. The functions and powers of the Assembly include, among others, setting general policy and long-term objectives, the prevention of conflicts with other conventions of a multilateral nature under certain conditions, and to provide for various specialized telecommunications services. The main objective of Intelsat is to maintain an international commercial communications satellite network to provide public service of high-quality to the entire world without discrimination.(22)

Each nation of Intelsat(22) has a share in the investment according to what fraction of the extra-terrestrial facilities that nation utilizes Each nation must make a contribution equal to the satisfaction of its capital investment requirements toward Intelsat. Intelsat procures its needs upon the basis of maintaining competitiveness among its suppliers. The headquarters of Intelsat is Washington, D. C. as is the headquarters of Comsat.

The existences of Comsat and Intelsat and their relationship to each other give an indication as to how the further course of space industrialization can proceed along routes not involving only direct government actions, whether those actions be that of the United States government or those nations signatory to the Intelsat agreement.

It is partly a result of deliberate planning and partly a matter of circumstance that the Comsat-Intelsat relationship developed the way that it did. After all, in 1962 Comsat could have tried to set up an international communications satellite network on its own without prior negotiations with the European nations. There would however have been great difficulties experienced, for example, because of disputes over frequency allocations and the question as to how far the territorial rights of a nation extended above it into the atmosphere and beyond. It is indisputable that Comsat, backed up as it was by NASA technology, had access to capabilities that were beyond that of any European nation or combination of nations both at the time of the founding of Comsat and the time of founding of Intelsat. Initially, in fact, Comsat realizing its superior position did try to act through bilateral negotiations with various European nations.[22] The Europeans apparently recognized the wisdom of not dealing with this approach and organized a negotiating committee to handle matters for all of the European nations. Consequently, it could be stated that the existence of a technological superiority by one nation, the United States of America, induced an increase in the cohesiveness and cooperation of a group of nations. It could be claimed, more or less seriously, that the creation of Comsat was a step on the way to the creation of a United States of Europe.

In 1962, 1964, and, even in 1973, the nations of Europe in no way could have established Intelsat as an operational entity without the aid of Comsat. It was not a situation that existed because the people and the resources of the United States were somehow "better" than the people and the resources, technological and otherwise, of Europe. The European community could have banded together and developed the satellites, launch vehicles, and associated systems so as to be considerably less dependent upon the United States in establishing the prime objective of Intelsat. Somehow, for Europe as a whole it was more convenient to simply hire Comsat to do the job. In a mild sort of way, it could be said that the United States position with respect to communications satellites has been analogous to the position of OPEC with respect to petroleum. The analogy is not complete because the strength of the European economy was not as critically dependent upon the establishment of an operational Intelsat as the United States economy is now dependent upon imported petroleum. It will still be several years before Europe will have the capability of the Comsat-NASA combination. Thus, basically because of a lack of the will to accomplish, it will have taken Europe about twenty five years to catch up to the United

States in this area. The success of Comsat has not been sufficiently appreciated in this country either in terms of economic policy or in terms of foreign policy.

Comsat has developed and provides to the world a product and a service in the basic area of communications that did not even exist twenty five years ago. In this manner, it has added and is still adding to the wealth of the United States. This situation indicates that drastically increased and sustained higher funding for NASA in the next few years could very probably put this nation into a position with respect to other aspects of space industrialization as this nation was put into with respect to communications satellites just before the creation of Comsat. The low priority given to civilian expenditures for the exploration and development of the extra-terrestrial environment as reflected in budgets of NASA over the last fifteen years has without question prevented the United States from already attaining this position. This low priority has already reduced the overall leadership (and in some specific areas completely eliminated leadership) of the United States with respect to Europe and the Soviet Union in the extra-terrestrial domain.

After a few years of higher sustained funding, the United States would then be in a position to establish a corporation that would essentially be a generalization of Comsat. Let this new corporation be called the Extra-terrestrial Development and Production Corporation (Edap). Edap would have the objective of selecting the aspects of space industrilization most promising for development, yet too complex and risky for any conventional private enterprise firm or combination of firms to handle, and expedite the realization of these aspects in profit-making terms. It would not concern itself with communications satellites or any other extra-terrestrial activities that Comsat or other firms would get involved with prior to the creation of Edap. The establishment of Edap would add a new enormous wealth-generating mechanism to the American economy. This entity would create, maintain, and lengthen American leadership in the overall process of space industrialization as part of the mandate of Edap would be to ceaselessly explore for new ways to profitably utilize the extraterrestrial environment.

In response to the existence of Edap, the European community could be spurred on to create a far more elaborate creation than Intelsat in order to procure the maximum amount of space industrialization benefits for itself. Perhaps, having learned from the past, and developments of recent years indicate that this is so, the new European entity could play a more active role in its own development than has occurred with Intelsat. Another possibility is that the members of the LDC group could become active participants in the European entity, overcoming their emphasis on merely re-distributing the existing wealth of the world, and join with Europe and the United States in the creation of new wealth.

The existence of the federal government created Comsat corporation has allowed the United States to exert a positive, constructive, and benign influence upon the world. This is the type of leadership which is the healthiest and most long-lasting. A nation which is truly the leader of the world has no need and no desire to exert its leadership by getting into wars and publishing weekly body counts of the enemy dead. It is a far greater victory to exert a strong leadership in such a way as to show the would-be enemy that the United States has a mode of operation which it would be in the best self-interest of the so-called enemy to adopt for the sake of its own citizens.

Edap would produce items for international trade and would be a powerful factor in assuring a favorable balance of trade for the United States in its dealings with the world. Comsat is already a vigorous growing organization. The proposed Edap organization would be even more vigorous and have a growth potential far transcending that of Comsat. Both through its international trade and its work with and in support of the organizational entities of foreign governments and international entities it would have more of an impact than has Comsat.

Since the death of President Kennedy the United States has been going through a period of psychological depression relieved at times by such events as those of the Apollo Project. A depressed people are not a pioneering people. Depressed people keep their faces in the mud. A person with his or her face in the mud cannot see the stars. An obsession with the present and an attitude of "What's in it for me now?" is ultimately self-destructive both for the individual and for the nation. There has been a negative feedback situation in the United States wherein a declining economy leads to a lowering of the hopes and expectations of the population and vice versa. Under such conditions, it is not unexpected that the position of NASA has deteriorated. If this depression of the United States continues for much longer, the nation may no longer be in a position to accelerate the process of space industrialization. Other societies and countries will then have the opportunity to fill a leadership vacuum and to reap the benefits that the United States choses to ignore in its sickness. A recent report of the General Accounting Office of the United States Congress warned about the occurrence of just this very possibility.(23) Although the report restricted itself to only one aspect of space industrialization, namely, space manufacturing, the conclusions of that report are valid for all space industrialization. The conclusions are that the United States government must spend more on space manufacturing research and development in the near term and provide encouragement and incentives for obtaining and increasing private enterprise investment.

One of the symptoms of decadence is the failure to rise to the challenge of agressively developing a major new frontier. By accelerating the process of space industrialization, the United States will demonstrate more than ever that it is a dynamic, vital, and growing nation.

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